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DECEMBER 1958

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A Journal for All Science and Mathematics Teachers

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SCHOOL SCIENCE AND MATHEMATICS

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Can a Machine Think?

A comparative study of the central nervous system and the digital computer

Edmond P. Odescalchi
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There are two ways of approaching that question. One is by definition. The textbooks of psychology define thinking as a sequence of symbolic processes based on past experience and learning. The operations of an electronic data processing machine certainly consist of a sequence of symbolic processes. As for experience and learning, experience is only a form of learning, and the programming of a machine corresponds to a man's education.

The other approach is the so called "black box" method. If we lock a man into a room and put a hypothetical digital computer into another room, and let us suppose we have a typewriter that is connected by cables to both, how could we determine in which room is the man? What questions could we ask, that the man could answer and the machine could not?

None. A digital computer can do anything from designing a jet plane or a nuclear reactor to judging a beauty contest. The IBM brain installed at the World Fair in Brussels can answer questions on world history from 4 B.C. to the present in less than a second.

Of course, we have to realize that nothing can come out of the machine that wasn't put in. But, on the other hand, nothing can come out of the human brain either that wasn't put in there.

Already in the seventeenth and eighteenth centuries the empiricist philosophers John Locke and David Hume reduced all knowledge to simple sensory experiences. They maintained that the human mind at

birth is like a blank surface on which are inscribed the impressions of the external world through the sense organs. Modern psychology confirms these views. If a man should be born without his senses and allowed to grow up, there wouldn't be a single conception in his head.

As a matter of fact the peripheral nervous system works exactly like the feed-in system of a digital computer. A nerve cell, called a neuron, obeys the all-or-none law. It either fires or it doesn't fire, there is no third possibility. If we stimulate a nerve up to a certain point, nothing will happen, if we reach that point or cross it, the nerve responds and sends out an electrochemical impulse. The strength of the impulse has no relation whatever to the amount of the stimulation.

The same law applies to data processing machines. We first convert the information into patterns of holes in cards. When we feed the cards into the machine, electrical impulses read the pattern of holes and convert them into timed electrical currents. Again, there are only two possibilities: there either is an electrical current or there isn't.

We can easily see how a nervous impulse travels along a fiber in the animal body. Such a pulse undoubtedly represents some chemical reaction within the fiber, but it also consists of an electrical change. This change can be recorded on a volt-meter if electrodes are placed on the neuron and led into an amplifier.

That clearly shows that a man's education actually starts when the first ray of light reaches his retina, the first soundwave his eardrums, etc. Every moment of our life a mass of information is pumped into our brain through our nervous system in the form of electrochemical impulses. Some of the neurons can fire as often as 1000 times a second. It is evident now that if we want to compare the thinking of a man with that of a machine we have to feed the same information, either facts or rules for using them, into the machine.

I know that many of my readers would like to interrupt me here and draw my attention to man's creativeness and inventiveness. Of course, we cannot analyze in a short article the full scope of man's technological and intellectual achievements, since that would fill many libraries. But, to see the point, let us examine two of man's simplest, but also greatest, inventions: the wheel and the alphabet. How did man invent the wheel? He probably saw a stone or a log roll. Now, after learning that round objects will roll, he was ready to "invent" a round object that was rolling.

The same principle applies to many of the characters of our alphabet. The letter "A" was developed from the Egyptian Apis, meaning sacred bull, and which was a regular drawing of a bull's head. That evolved into the Phoenician Aleph, which in turn became the Greek

Alpha and later the Roman "A." If we turn the letter "A" upside down we can still see, with a little imagination, the general outlines of a bull's face and horns.

These examples show that man cannot create new things out of nothing. He can only make combinations, generalizations, deductions and associations. The result we call "new." Actually it is a synthesis, the components of it were fed into the brain by either formal learning or experience.

Every abstract conception evolved from very concrete origins, whether it is a rocket to the moon or the theory of relativity. Every new combination makes again other combinations possible.

Thinking consists mainly of storing information and referring to it by a process of learning and remembering, and of applying that knowledge to different situations.

A digital computer can store information and refer to it. It can perform the most complex mathematical operations and logical deductions, and verify the results. It can reason and make decisions. It can determine its own instructions and work unattended.

How can a machine do all these things? How does an electronic brain handle information? The smallest unit of information is a "yes" or a "no," a "true" or a "false," a "1" or a "0," etc. On a nerve fiber or on an electric wire they correspond to an impulse or no impulse. This is called a binary digit and is commonly used as the unit of information.

Each decimal digit, from 0 to 9, is therefore equivalent to 4 units of information, since 4 binary digits (1 or 0) have 16 possible arrangements, which is more than we need. One of the 26 letters of the English alphabet is equivalent to 5 units of information.

Information travels in the machine with a velocity of 186,000 miles per second, the speed of an electric current, while nervous impulses in the animal body can reach a maximum velocity of only 300 feet per second.

The brain contains about 10 billion nerve cells. If each of these neurons could individually be impulsed or not impulsed, then the human brain could conceivably handle 10 billion units of information. The same amount can easily be stored in five cubic feet of space filled with magnetic tape.

In a digital computer all the complex mathematical problems are broken down into their component arithmetical operations by a process known as numerical analysis. As pointed out before only two digits are used "1" and "0." For logical reasoning the machine uses mostly the algebra of logic, also called Boolean algebra, after the British mathematician George Boole, who introduced it in his monumental work *The Laws of Thought*. It deals especially with logical

relations expressed in such words as "or," "and," "not," "else," "if," "than," "only."

The principle of Boolean algebra is that it replaces the values "true" and "false" with the numbers 1 and 0. Since they are numbers, we can add them, subtract them and otherwise manipulate them in calculating logical truth.

The IBM 705 Electronic Data Processing Machine can perform 8400 additions or subtractions, 1350 multiplications, 550 divisions, and 29,400 logical decisions per second. It can make computations in a few minutes that would take a staff of skilled mathematicians many generations to accomplish.

In general, a computer is made up of input and output devices, whereby information can go into the machine and come out of it, devices where information can be stored, and mechanisms to carry out mathematical and logical operations. It also has a control system, which guides the machine to perform a sequence of operations.

In order to accomplish all this a digital computer depends on a system called servomechanism, which consists of feedback from the output. That way the error between the two qualities, input and output, may be controlled in a prescribed manner.

It has to be pointed out that we don't know too much about how the human brain works. We know, however, that it has a topographical arrangement. Sensory experiences (except smell) proceed to the thalamus and are relayed from there to their particular area in the cerebral cortex. If, for example, the visual area of the cortex is stimulated electrically, it produces visual images. Or, if the part of the brain, where certain information is stored, is damaged by an accident, the person has to relearn the information destroyed.

The brain of a genius can not be distinguished from that of a mentally retarded person. There is no visible difference between the brains of Albert Einstein and Joe Doe. Since the central nervous system consists of a large number of neurons, billions of them, as mentioned earlier, there is no doubt that the difference lies in the network of connecting nerves.

The similarities between the nervous system and the digital computer led to the birth of the new science of cybernetics. The word was coined by Dr. Norbert Wiener, professor of mathematics at the Massachusetts Institute of Technology. It embraces the field of study dealing with the common elements of control and communication in the animal and the machine. There is reason to believe that the human mind functions as an extremely elaborate and refined cybernetic device.

Cybernetics includes the theory of information and its measurement, the concept of communication as a statistical problem in

which messages not sent play an equal role with messages sent, etc. It includes also the theory of apparatus that retains information in a sort of memory and that adapts its performance to improve its own efficiency by a sort of "learning" process.

Some of the electronic brains, like the ones in antiaircraft range-finders and guided missiles, are capable of collating stored data and information that they accumulate by their own observation, then making predictions and decisions.

We can see that electronic brains can think much faster and much more accurately than any man.

Computers can be constructed to play an expert game of chess, to compose classical music, or to translate Russian into English. IBM computers are used to decipher the illegible parts of the Dead Sea Scrolls through the statistical structure of the language.

Computers can compare and select. But how can a machine make judgments and express opinions? Both, judgments and opinions are based on previous information. The only difference between a rule and a judgment is that in case of a judgment some of the factors being considered are either incomplete or hard to express. The more information is lacking the larger the tolerance for errors.

The word "opinion" has to be handled with caution, for it carries certain aphrotetic undertones. An opinion may be based on prejudices and someone might interject that here we found something a machine cannot have. I have to point out that prejudices are acquired, we are not born with them. We could easily build machines with prejudices and even machines that lie. But who would buy them?

Thinking machines are comparative newcomers on the technological scene. The first computer to use electronic tubes (18,000 of them) for calculating was ENIAC (Electronic Numerical Integrator and Calculator), created at the Moore School of Electrical Engineering of the University of Pennsylvania. It was completed in 1945 and was the first one to reach the speed of 5000 additions a second.

Progress is being made rapidly. By the time a data processing machine is ready for production it is usually obsolete. Digital computers could be constructed to run automatic factories, to make automatic repairs, and even to reproduce themselves. They are reliable and capable of infinite complications.

In spite of the terrific powers and abilities of present-day machines, the age of electronic brains has just begun. No one can afford to be unaware of their significance.

MEAT SPOILAGE PROBLEM ATTACKED

Dip that thick, juicy steak in an antibiotic solution, expose it to radiation, refrigerate it and forget those spoilage problems.

Centripetal or Centrifugal Force?

Charles A. Compton
Phillips Exeter Academy, Exeter, New Hampshire

Amidst the furor over science in education one factor seems certain: whatever we do we must be sure that we do not teach misconceptions. Nowhere is error heaped on error in such profusion and with such confusion as in the parts of the physics and general science texts that discuss centrifugal forces. That two terms such as centrifugal force and centripetal force could be so constantly misapplied year after year is a sad commentary on our textbook writers, editors, and users.

The confusion is generally based upon a simple misconception: that centrifugal force is exerted on any body that is moving in a curved path. A few examples may help point out the arguments most frequently encountered.

In a brief article in SCHOOL SCIENCE AND MATHEMATICS (56: 370. May, 1956) the question of a tipping bicycle rider is considered. If he tips to the right, the rider turns the front wheels to the right in order to return to the vertical. Curved motion, states the analysis, causes centrifugal force which acts to the left on the center of gravity of the rider-bicycle system. This force "pushes" the system back to the vertical.

In a brand new edition of a popular school science text the authors make a correct definition of the two central forces by giving an example. A pail is pulled into a circle by centripetal force, while the pail pulls on the rope with centrifugal force. Within a page the following two statements are made:

> "Centrifugal force causes mud to fly from rotating automobile wheels."
> "As wet clothes are whirled in cylinders the water is removed through small holes by centrifugal force."

These same ideas turn up when someone asks the now pertinent question: What holds a satellite up? The reply that is usually given, and which appears in print frequently, is that centrifugal force equals the pull of gravity. Thus, the outward force on the satellite equals the inward pull.

Now, why are these misapplications of the centrifugal force concept so important? After all, they give the correct numerical results. The importance is that thoughtless teachers have blundered for years, and students have equally thoughtlessly parroted these blunders. No one seems concerned with the inconsistencies, or with the implications of the errors. No one asks whether the centrifugal and centripetal forces act on the same body. It seems to be enough that each can be expressed as mv^2/r. Yet the consequences of a "centrifugal

force" acting outward on a body that moves in curved motion are almost staggering.

1. To move in a curve evidently requires that a body be acted upon by a force which is directed *away* from the center of curvature. To turn left on a bicycle means that something pulls to the right on the center of gravity.
2. Mud tends to move in a circle on a wheel unless pushed out by centrifugal force. In other words, straight line motion of mud requires a force. The same holds for satellites, natural or artificial.
3. In each of the above examples we find a strange concept emerging. This "centrifugal" force which acts on bicycles, mud, water-in-clothes, and so on, is acting on bodies that move in curved paths. Whence comes this force? What mystical nonphysical entity gives rise to the "centrifugal" force? What is there out in space pulling outward on satellites, or on bicycles or mud?

Carried to their extremes, the above three arguments can be made to overthrow the very basis of Newtonian mechanics. No school teacher wants to admit that forces arise without cause or agent. Yet we sit back and accept false statements without ever wondering to what conclusions they may lead.

Since the rational explanations of the motions described are simple, this reference to metaphysical forces is unnecessary as well as erroneous. When moving in a curve a bicycle is pulled into that curve by frictional forces between wheel and ground. Pulling to the right, this centripetal force exerts a torque on the bicycle that returns the bicycle to the vertical. If the forces between mud and wheel cannot support curved motion the mud flies off; it is not a force which pulls it off but the lack of a centripetal force which makes it impossible for the mud to stay on the wheel. Nothing holds the artificial satellite up; gravity provides centripetal force which holds the satellite down. The centrifugal force, about which so much is said, is the reaction force which is exerted by the satellite on the earth.

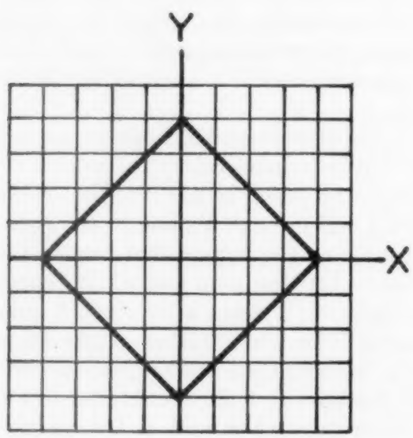
Students and teachers should use the satellite problem as a basis for further investigation, for only in this way can any isolated phenomenon became part of a more general understanding of nature. It might be interesting, for example, to study a bullet shot directly forward from the satellite. Let the student find that the satellite will pass this bullet (which will move into a new orbit of greater radius). It need not take long to develop an entire satellite system which can suddenly be shown to resemble the solar system in almost every particular.

If we must talk about centrifugal forces, let us do so with more care than has been shown in the past. Let us be aware of the conclusions that can be drawn from our statements. In fact, let us start asking that some conclusions be drawn and stop being content to have our students repeat what we say to them even when we have stated nonsense. It is not the purpose of education, especially science education, to train parrots.

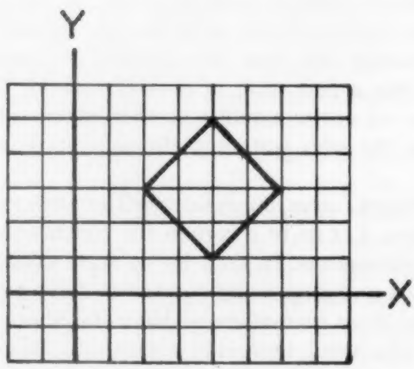
Equations of Some Common Geometric Figures

John L. Spence
Corpus Christi, Texas

Squares, diamonds, rectangles, trapezoids, etc. are among the common geometric figures. Although the equations of these figures are not discussed in texts on analytical geometry, they may be of interest to the student. The absolute value notation offers a simple means of writing the equations of these figures, as illustrated by the following examples.



$|x|+|y|=4$
A square with center at the origin.

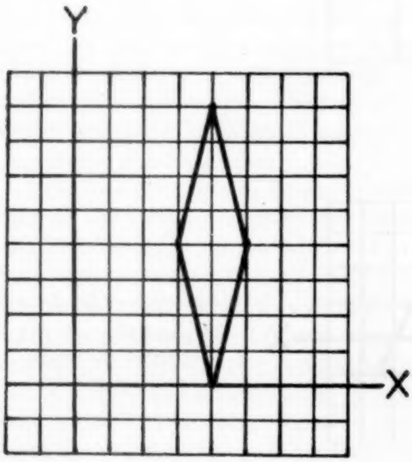


$|x-4|+|y-3|=2$
A square with center at the point (4, 3).

In performing calculus operations on absolute value functions, the following rule supplements the standard rules for differentiation and integration:

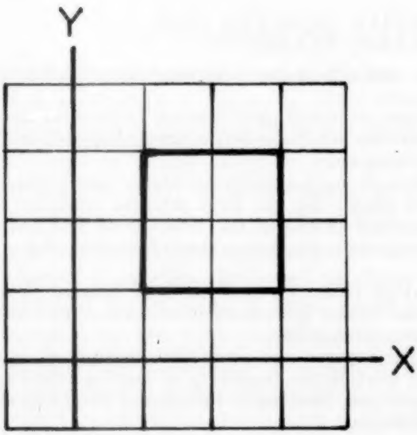
$$\frac{d\,|U|^n}{dx} = \frac{n\,|U|^n}{U}\cdot\frac{dU}{dx}$$

where U is any function of x.



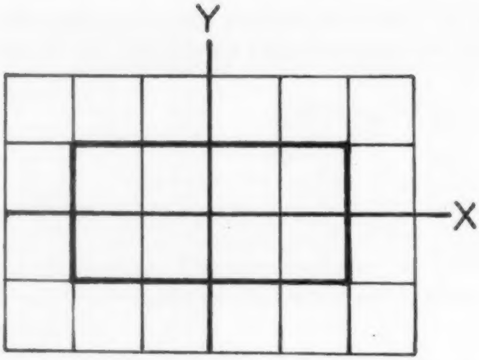
$4|x-4| + |y-4| = 4$

A diamond with center at the point (4, 4)



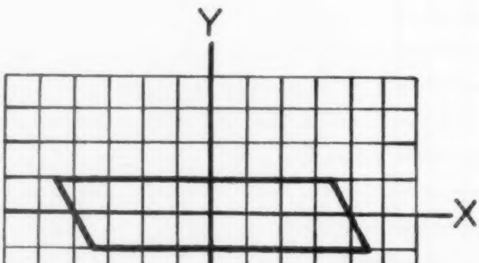
$|x-y| + |x+y-4| = 2$

A square with center at the point (2, 2) and sides parallel to the coordinate axis.



$|x-2y|+|x+2y|=4$

A rectangle with center at the origin. Its height is 2 and its length is 4.



$|-2x-9y|+|2x-7y|=16$

A parallelogram with center at the origin.

FIRST RADIOACTIVE INJECTED PINE TREES FELLED, EXAMINED

"Hot" trees may help the tire and cellophane industries toward greater production efficiency and lowered costs.

Using ordinary hypodermic syringes, scientists have injected radioactive carbon, C-14, into two-year-old pine trees for one of the first controlled experiments in the study of cellulose growth in living trees.

First results indicate that there is a strong possibility for higher future yields of cellulose per tree plus improved quality for the large cellulose consumers. Scientists have completed the dissection of one of the "hot" trees and have studies already underway using the various tagged components from bark, lignin, cellulose and the hemi-celluloses.

Cellulose in quality suitable for high tenacity rayon has been isolated from the radioactive portion of the tree for further laboratory investigation, particularly in connection with rayon process mechanisms.

The work is still in the preliminary stages and significant conclusions can not be firmly drawn. But, this first work in the feasibility of tagging cellulose as it grows in the tree has been positive, showing a substantial lay-down in growth processes with only minor diffusion.

Needed: Science Stories for Young Readers

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Introduction

Many science books and stories have been written for children. Few, however, have been written for children in the first four grades in which the writer truly had in mind the readers' interests, abilities and limitations.

For example, the author was impatient when she had to use a third-grade vocabulary in her story on rockets, since children even in first grade are interested in space travel. On examination of some dozen children's books on the subject of rockets, including one "for the six- to ten-year-olds," she found only one which might be read easily by an average fourth grader.

This does not seem to be the exception. Rather it seems to be the *rule*. At the early elementary age when a love for, and understanding of science can be cultivated, there are few stories in which writers have made a conscientious effort to write the story in a simple fashion. It is unfortunate that this should be the case when scientists are needed so desperately, because a good foundation in science in the early grades will encourage young people to train for such a profession.

The author has attempted to establish goals that should be taken into consideration when science stories for children are written. Methods of attaining these goals are discussed, and three informative stories have been written by the author to illustrate the use of these methods. The three stories are written on different subjects, and for different grade levels.

Some Principles for Writing Science Stories

An attempt must be made to discover the factors that make a story or book interesting to children. The author has been an elementary teacher and has observed the general interests as well as the reading interests of young children. She also has reviewed a great deal of research in order to supplement her observations. Such work with interests is primary in reaching this goal.

Any story must use as a basis a vocabulary suitable for the children for whom it is written. In order to discover the words that should be mastered by students at the various grade levels, the word lists accompanying the three reading series were examined. In compiling a list of words to be used in a simple story, the word lists in the first grade manuals of the reading series of Ginn and Company; Houghton Mifflin; and Scott, Foresman and Company were examined. If a

word appeared in two of the three word lists, it became part of the author's list of words to be used in stories for second grade children or above. The second grade manuals of the same series were examined in compiling a basic vocabulary for third graders and the third grade manuals for fourth graders.

Each new word must be introduced clearly. By "new word" is meant any word used for the first time, which is not a part of the vocabulary list for that level of story. Every word in a child's story, with very few exceptions, should be in his oral vocabulary. Therefore, when a new sight word is introduced, the idea is to help the child associate the printed word with his oral understanding of it. This can be done in three ways: (1) by picture, (2) by context, or (3) by phonics which the reader has mastered along with the vocabulary being used in the story. Of course, there are certain new words that need no introduction because they are an integral part of the modern child's sight vocabulary, such as *television*, *radio*, and *jet*. However, when in doubt, such words should be introduced as new ones. The author has introduced few words that are not simple phonetically. Most words are introduced in contexts that suggest strongly the words' meanings. The few words which are "hard to get across" in context would be introduced by pictures if these stories were printed for consumption by children.

A minimal number of new words should be introduced. No word should be introduced which is not essential to make the story more interesting or the ideas more easily understood. The reader can see how necessary all the new words are in the following stories. Even then, quite a large number of new words were needed to name, describe or explain certain aspects of science.

Some method must be used to discover scientifically the degree of difficulty of the story. Writers should be sure their stories aren't too complicated for the young readers who will read them. The author has used the Wheeler-Smith formula for readability. The number of polysyllabic words and the average length of sentences in a story or book are components considered in this formula. Writers must remember that for independent reading, the degree of difficulty must be a grade below the grade level of the reader.

Writers must not indiscriminately use variants, contractions, compounds or irregular verb forms of known words without considering them as new words. The author used as her guide in this goal the Houghton Mifflin reading series. In the teaching manuals of each grade of this series, together with the vocabulary introduced by the end of the grade, the skills taught for changing root words are also listed. It seems logical that while using a certain grade vocabulary, writers

may also use the variants, compounds and contractions taught in these grades. The following chart indicates the liberties that may be taken while using the first, second and third grade vocabularies.

VARIATIONS OF ROOT WORDS PERMISSIBLE WITHOUT INTRODUCING THE RESULT AS A NEW WORD

Variation	Using Vocabulary of Grade		
	I	II	III
s	×	×	×
ing	×	×	×
ed	×	×	×
es		×	×
d		×	×
er		×	×
est		×	×
y		×	×
ly		×	×
n		×	×
en		×	×
m			×
ful		×	×
less			×
ness			×
able			×
un (prefix)		×	×
re (prefix)			×
dis (prefix)			×
mis (prefix)			×
Compounds		×	×
Simple Contractions			×
Irregular forms of known verbs		Always introduced	

Subject matter must be comprehensible to the grade level for which the story is being written. When writers truly create science stories for young readers, not only will more attention be paid in using the vocabulary of the child, but also to explaining in experiences of the child. An example: "A tornado looks like an ice cream cone." *Not* "A tornado looks like a funnel." Both *cone* and *funnel* are new words, but the child is much more likely to have had experience with an ice cream cone than with a funnel. Contact with children of the age for which the piece is being written is the most logical way of learning how to make ideas comprehensible.

The author's attempt to be understood is quite evident. In several cases, pictures would be necessary to clarify concepts new to the young reader. Such is true with the explanation of distances in the second story, air pressure in the third story and the location and size of planets in the third story.

A short explanation precedes each story concerning its readability, interest level, vocabulary level, use as to grade level of readers, and purpose. New words, in their initial use in each story, are written in italics.

SEEDS THAT *TRAVEL*

Vocabulary Used: First grade
Readability: Difficult primer
Interest Level: First grade through fourth grade
For Children:
- In first grade—above average
- In second grade—average and above
- In third grade—all
- In fourth grade—below average
- In fifth grade—below average

Purpose of story: This story was written to interest children in observation of nature (particularly with plants) and to interest them in additional reading on the subject since this story is really just an "appetizer."

POP GUNS

Pop! Pop! Pop!

"What was that *noise?*" asked Dick.

"I don't know," said Tom. "It *sounded* like a pop gun popping out *corks*."

The boys were walking in the woods. They heard that sound again.

Pop! Pop! Pop!

"Something *hit* me!" said Tom. "Did you do it?"

"No!" said Dick.

Pop!

"There it goes again."

"Look over there," said Dick. "Something just popped from that funny brown plant."

Pop!

"I saw it that time," said Tom.

"That plant is popping out little balls."

"Just like a pop gun *shoots* out corks," said Tom. "Here is one of the balls from that plant, on the back of my hand."

"Let's see," said Dick. "It looks like a little seed."

"How do you like that? A plant that shoots out seeds like a gun!"

PARACHUTES AND *GLIDERS* TOO

"Do you know what?" asked Dick. "Some plants have seeds with parachutes!"

"You mean like men have when they jump from *airplanes?* Something must have hit you hard on the head," laughed Tom.

"No, I mean it. Here comes a seed on a parachute right now."

"Say, you are right. That *dandelion* seed has a parachute of white

fuzz. And now, here is one for you," said Tom. "What plant seed has a glider just like airplanes *pull* behind them?"

"I give up! What seed?"

"*Maple* tree seeds. They have big *wings* that help them glide away."

Why Seeds Travel

"All these seeds can travel," said Dick. "Why do you think all of these seeds are made so that they can?"

"Let's see," said Tom. "If seeds could not travel, they would just fall from the plant and start *growing*."

"But if the little plant were under a big one, how could it get any *sun?*"

"That's right. It could not. We learned in school that plants need water and sun or they will not grow. The little plant could not live under the big one."

"That must be why they can travel. So they can get to a new home where they can grow up."

"When we get home, Dick, let's ask Father if we are right. He will know."

At Home

After the boys' father heard Dick's and Tom's story, he said, "That plant you saw shooting out seeds is called *Witch Hazel*. And you are right in thinking that seeds are made to travel so that they can get to new homes where they can grow. Do you know that some plants that grow in or by water have seeds which go to their new homes in boats? Some seeds travel on or in dogs, cats, birds and so on. You ask Miss Green at school tomorrow to help you find a book about seeds that travel."

"We will!" said the boys.

"Say," Tom laughed. "Plants have many ways of going to new homes. We could go by many of their ways too. We could go by glider, boat, dog back or maybe parachute. But I would just as soon not travel to a new home by being popped out of a gun!"

Storms Coming

Vocabulary Used: Second grade
Readability: Second Grade
Interest Level: Any elementary grade in tornado areas
For Children:
- In second grade—above average
- In third grade—average or above
- In fourth grade—all
- In fifth grade—all
- In sixth grade—below average and average

Purpose of Story: This story contains almost all information needed by a child to make his home, family and self safe in a tornado. Therefore it is a good safety story for elementary children. Another aim is to provide facts that will lessen the panic of many children when tornado warnings are out.

Jim rode home as fast as he could go. "How hot and sticky it is," he thought. "And the wind is so strong! I can hardly make this *bike* go in a straight *path*. Look at those dark green *clouds* up there. They are standing on end. Father said I would see that kind of cloud before I got home."

Jim's father was one of the men who tell us about the *weather*. They tell us if the next day will be sunny or rainy. Everybody had been so busy when Jim had gone to see his father at work.

"Glad you came here before going home," Father had said. "Mother is not at home and we are in for some *tornadoes*.

"A tornado is a strong wind that goes round and round *spinning* like a top. It may look like a rope dropped down out of the clouds. It may look like an elephant's trunk. It may look like a big black ice cream *cone*.

"Tornadoes do strange and bad things. They pick up *dirt* off the ground. They pick up *anything* that gets in their paths. Tornadoes have been known to pick up chairs in backyards and drop them on fields or on house tops many *miles* away. They pick up cars like feathers.

"Tornadoes can blow a piece of wood so hard that it ends up sticking through the side of a barn. Often tornadoes blow down trees—even buildings."

Father had told Jim what must be done to make the animals and the farm *safe* in case of a tornado.

"Now hurry home!"

"But I'm afraid!" Jim had told his Father.

"You should be!" was Father's answer. "Tornadoes are nothing to laugh at. But it is not at all likely that one will touch our farm. Many, many people are told in tornado weather that there may be a tornado that day. But of these people, just a few or maybe no one will even see one.

"This is why. The path of a tornado is *usually* not more than 20 miles long. That is not as far as we go in our car in 30 *minutes*. And the path is usually not more than 440 yards wide. That is about four football fields put end to end. Many times tornadoes never even touch ground. Other times they jump over spots along their paths.

"You should be afraid! But use your head. The people who are are hurt in tornadoes are usually ones who don't use their heads. They get so afraid that they do silly things. *Sometimes* they run out into the street. That is a very bad place to be in a tornado. Other

times they run right into the path of a tornado. Now I'll tell you what to do to make the farm *safe*. You will be O.K. if you do as I tell you. And remember: Use your head."

As Jim rode home, he was thinking of all the things Father had said to do.

Home at last! Jim jumped off his bike and put it away.

"Let's see. The first thing Father said to do was to get the animals inside."

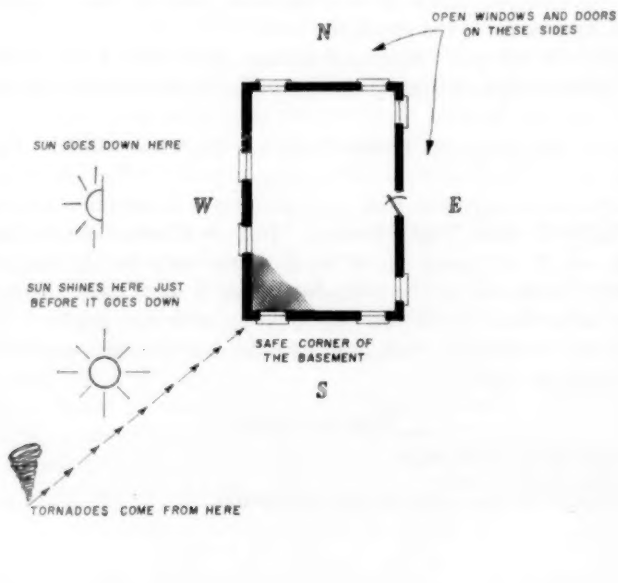
Jim got the chickens into the chicken house. He put the pigs and two cows in the barn. Then he ran to the front pasture to get his riding horse. As he ran he watched the place where the sun *shines* just before it goes down. That is the place from which most tornadoes come. He also looked out for the nearest *ditch* or hole. Father had said if Jim saw a tornado when he was out in the open, to *lie* flat in the nearest ditch.

When his horse was safe in the barn, Jim closed the barn door and ran to the house. The wind was getting stronger. The dark green clouds were getting blacker.

"Now, I've got to open some windows. But which ones?" Jim took out a picture which Father had drawn for him. It told him which windows to open.

He opened windows on the side of the house across from the side from which the tornado would come.

"Now get down to the *basement*. But first I must get my *flashlight*.



I will need light. Oh, yes. My *radio*. It will tell me when the storm is over and when it is safe to go out again. Now that I have the flashlight and radio I will go down to the basement." Jim was thinking through each step as he did it. "Get on the side where the sun shines just before it goes down. Oh, yes. Get away from all the windows. Father told me to be sure to do that. And get under something. This old table will do."

Just then Jim heard a noise at the back door.

"Oh, poor Blacky! I left him in the yard!" Jim ran to let his dog in. As he opened the door, the wind almost blew it out of his hands.

"Listen, Blacky! Airplanes! The wind sounds like the roaring of a hundred airplanes. Father said it would sound like that just before the tornado. Hurry, Blacky! Hurry."

Under the table again, Jim knew he was safe. He put his head down on Blacky's side. It was so quiet now. Jim turned on his radio to hear about the storm. Soft music was playing and he was so tired.

"Well, look at the boy who was afraid of the tornado—sleeping like a baby," Jim heard Father say.

"Was I sleeping? Is the storm over?"

"Yes. Yes. You must have been sleeping through the whole thing."

Just then Mother came in the back door and ran down the stairs. "Is everyone all right? Oh, yes!" she answered herself when she saw Father and Jim. She ran to them and put her arms around them both.

"Say," she said then with a laugh. "What have you two been doing today? A tree is down right next to the house. There are leaves, wood—all kinds of things all over the yard. And all that is holding up the chicken house is the chickens."

"Well, I'll tell you, Mother," Father said with a big smile. We had a little tornado around here today, and I don't mean Jim and his dog!"

"And I was sleeping! I missed out on the whole thing," Jim said sadly.

"Listen to the boy who took such good care of our farm and himself too. Tell you what," said Father. "Just so it won't seem that you missed out. I am going up in an airplane early in the morning to follow the path cut by the tornado. I hear it went right through our field of corn. How would you like to go up with me, Jim?"

"Oh, boy!" said Jim. "Oh, boy! I would sleep through ten tornadoes for an airplane ride!"

Rockets Away

Vocabulary Used: Third grade
Readability: Second grade
Interest Level: Second grade through sixth grade

For Children:
In third grade—above average
In fourth grade—average and above
In fifth grade—all
In sixth grade—all
Purpose of story: This story introduces principles needed to understand rockets and allied subjects so the children who read it will have a better chance to understand the many good but difficult books on rockets written for them.

How Rockets Work

Tom and his father watched as the sky-rockets roared up into the air. A splash of colored sparks fell down over the lake. Finally the yearly show of fireworks was over.

As they left the park and walked home, Tom's father said, "You know, Tom, some day rockets will take men up into *space*. They will work just like the sky-rockets did tonight."

"Really, Father?" asked Tom.

"Yes. They used gun *powder* in the sky-rockets tonight. A match set this powder on fire. Then it turned into hot *gases*. When things turn into gas, they take up more space. You know that when you heat water in a pan, the water becomes gas, or as we say, boils. You must watch it or it will boil over. In a rocket the gases have only one place to get out. They 'boil over' out the tail. When the gases roar out, the rocket *shoots* into the sky."

"I don't understand," said Tom. "What makes the rocket move?"

"Well," began Father, "When you shoot a gun, the *bullet* is *forced* in one direction. You feel the push or kick of the gun in the other direction.

"When I shoot that old shotgun of mine, it kicks back so hard it almost knocks me over. The same sort of kick will also send the rocket into space. The gases will come out of the rocket just like the bullet out of the gun. This will force the rocket to take off just as the gun kicks in the other direction from the fired bullet.

"The rockets that take up a man-made moon work the same way. Space ships will too."

"But, Father, all the sky-rockets came right back down. I know the pull of the earth, or *gravity*, did that."

"You're right, Tom. If it weren't for gravity, you and I would be floating home now instead of walking. That cap on your head would be *floating* too. If it weren't for gravity, everything that wasn't held down would be floating about."

"Yes, I know all of that. But why won't gravity pull down the rocket ships just as it pulled down the sky-rockets? Even a man-made moon is pulled down after a while. Why will the rocket ships keep moving away from the Earth until they get where they're going?"

"Well, you see, Tom, when you get far out into space, there is no air to push against things. The gravity of the Earth has almost no pull way out there. No sound. No anything.

"Space ships, when they have gotten this far from the Earth, will just *coast*, as you do on your bicycle. The push of air and the pull of gravity help to slow you down when you coast. But there will be little to slow the space ship down.

"If the ship is going to the moon, it will keep on coasting until the gravity of the moon pulls it down. Then the ship will land on the moon.

"The sky-rockets we saw tonight went up only a short way. Even the man-made moons haven't gone up far enough to get to the big nothingness.

"But, Father, why can a man-made moon stay up at all if they can't get away from gravity?"

"I'll try to answer you, Tom. Let's see. I think I saw you using a force the other day that can be stronger than gravity."

"I was? I wasn't floating or walking up the walls, was I?"

"No, but you were doing something that shows that gravity doesn't always pull things down. While you were swinging a chain with your house key at the end of it, the force of gravity didn't make the key fall, did it?"

"No, but when I stopped swinging the chain, the key fell."

"Right. But as long as you kept that key going around and around very fast, you were using another force which can be stronger than gravity. It is called *centrifugal* force. As your key slowed down in the circle around your head, centrifugal force was smaller than the force of gravity and your key was pulled down.

"The same thing happens with a man-made moon. When the moons are rocketed up into the sky, they go round and round the Earth very fast. But some force or forces slow down the moons. Finally, as your key fell when it stopped going around so fast, the moons also fall when they are slowed down. Gravity is greater than centrifugal force and pulls them down to the Earth.

"Boy, that's pretty neat! Father, where did you learn all about rockets?"

Father looked now as he did when Mother caught him eating cookies just before dinner. "Well," he laughed, "I bought you a book about space ships for your birthday. I just finished reading it. It sure was interesting."

"Just like a father. He buys a train for you and he plays with it. He buys a book for you and he reads it.

"If you're finished, may I have my birthday present?" Tom laughed.

"Yes, you may. Then tomorrow you'll know all about rockets too," laughed Father.

Aboard a Space Ship

Tom sat in bed eating an apple and a piece of cake. A *bottle* of pop sat next to him on a table. He was so busy reading about rockets. It was now very late. He closed his book and looked out the window.

He saw something strange in the moonlight. A shiny piece of silver stood at the top of a hill nearby. Tom jumped out of bed and ran to the hill. The higher he climbed, the more silver he could see. At the top of the hill he looked down. He couldn't believe what he saw. There, in front of him, nose pointing to the sky, was a giant rocket ship. Something was written on its side. As he walked down the hill he could make out what it said. "Back to *Jupiter* or else!" it read.

"Jupiter!" thought Tom. "That's the biggest *planet*. That ship must belong to men from Jupiter."

Sleeping beside the ship was a giant man. Tom crept closer.

Stairs led up the nose of the ship. Tom knew he shouldn't go up the stairs. But he did anyway, moving quietly. Up, up, he climbed until he reached a door in the nose. He pulled at the door. It was heavy. Slowly it opened!

Tom looked inside. No one was there. He went in.

There were beds near the nose of the ship. Pull-out boxes were built into the walls. Tom pulled one of these boxes out. In it were many bottles. Some of them were filled with little colored balls. In others there was something that looked like water.

Tom was so interested in the bottles that he didn't hear the noises out on the stairs.

The door opened. In walked three giants. They were as surprised to see Tom as he was to see them.

"An Earth boy," one said.

"What are you doing on our ship," said another.

Tom could hardly speak. "I-I saw your ship. The man out there was asleep so I just walked up the stairs and came in!"

"Oh, you just came in!" said the third man.

"I'm so interested in space ships. I just had to see what this one was like."

"Say, if you're so interested in space travel, maybe we can tell you a few things you'd like to know," said one giant.

"But first you'll have to tell us some things we want to know about your Earth," said another.

"We saw that you have *jet* planes now. I suppose you're going to visit Jupiter some day in jets," said the third giant as he smiled and winked at the other two.

"No! We know that we can't use airplanes or jets," answered Tom. "The *fuel* which makes them go needs air to make it burn. Airplanes need air to hold them up. Since there isn't any air far from Earth, airplanes and jets won't work. And besides, the closest we're planning to get to Jupiter is on one of its twelve moons. Jupiter has so much gravity we'd never get off again if we ever landed. Say, how did you get off?" asked Tom.

"If we told you," laughed one giant, "we might have Earth people dropping in to see us on Jupiter. We wouldn't like that!"

The giants went on asking Tom about life on the Earth.

Finally one giant said, "We're going to have to get him out of here before Top Man gets back."

"But you promised to tell me about your rocket," said Tom.

"O.K. What do you want to know?"

"What is in those bottles I was looking at when you came in?" asked Tom.

"Food for the trip. Some of the bottles are filled with *pills*. Taking a pill is much easier than fixing and eating other kinds of food. So we have one pill twice a day. The other bottles are filled with drinks."

"But I couldn't pour anything out," said Tom.

"Pour?" said a giant. "Remember—no gravity in space—nothing falls. In space if you could pour drinks out of these bottles, the drink wouldn't fall into your cup. It would float in space at just the place it came out of the bottle."

"Our bottles are made so that you push in on the sides to *squeeze* the drink into your mouth," said another giant.

"Oh! A squeeze bottle! We have a lot of them in our house. I should have known enough to try squeezing the drink out.

"But you said that nothing would fall in space. You mean that if I tripped over something, I couldn't fall to the floor?"

"That's right," laughed the giants.

"Space would be a good place to learn to ride a bicycle then."

"Say," Tom went on, "how do you start the rocket?"

"Come here to Top Man's chair bed," said the third giant. See this thing here? All you have to do is to push it and we're off!"

"Your rocket has three parts," said Tom. "Are the bottom two parts filled with rocket fuel?"

"Yes," answered a giant. "It takes only one minute to use up the fuel in the tail part of our rocket. Then that part drops off. The fuel in the next part is used up in another two minutes and it drops off. Then the engine in the nose takes over. All the time we are going faster and faster. Five minutes after we take off, we're out in space. There is no air to slow us down and no gravity to pull us back to Earth, so we turn off the engine and just coast."

"Your rocket works just like the ones that we're building," said Tom.

Right then there was a noise out on the stairs. A loud voice called, "Come on men. Time to take off!"

"That's Top Man!" said one of the giants to Tom. You've got to hide. If he finds you it will be too bad!"

"Here," said another giant. "Hide in this box. You'll have to go back to Jupiter with us."

"I'm not going anywhere with you! I'm going home!"

"Into the box, boy!" the giant repeated.

"Let go of me," shouted Tom. "Besides, you aren't even real! You couldn't be. Jupiter is so far from the sun that there couldn't be any life on it. It's too cold. Anyway, if there were life on another planet, there wouldn't be people like us. And if there were some kind of people, they sure wouldn't talk the same way I do!"

As Tom was saying this, he was falling—falling—falling—right—into—bed!

Tom rubbed his eyes and looked around. He looked at the pop bottle by his bed and at the apple he had been eating. His book was open to a picture of a silver rocket ship ready to take off.

"What a *dream!*" Tom said. "And all because I read about rockets and ate so much before bed. I'll never sleep again! After that dream, I would be afraid to even close my eyes."

And with that, Tom turned over and was sound asleep in a wink.

Geography Tests

In response to many requests from teachers the National Council on Geographic Education is attempting to answer the need for achievement tests at all grade levels of geographic materials.

The Committee on Tests of this organization is compiling a handbook on *Measurement and Evaluation in Geography*. This handbook will show how to construct tests. It will also give the correct procedures for evaluating a test. It will stress the use of good educational objectives as the basis for all measurement and evaluation.

The Committee would like to have samples of complete tests or individual questions at all grade levels of Geography. These questions are to be used as illustrative material for the handbook. We would like both subjective and objective type questions for all elementary, secondary, and college grade levels. We want those testing skills, attitudes, and appreciations as well as those testing the subject matter of Geography. Please designate the grade level for which your material is to be used and send to:

Berenice M. Casper, Chairman
Committee on Tests
National Council of Geographic Education
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Lincoln 10, Nebraska

Algebra of Complex Numbers

Warren Strickland
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Assuming the properties of real numbers, and accepting

i) a complex number is an ordered pair (x, y) of real numbers,

ii) if (x_1, y_1) is a complex number, and (x_2, y_2) is a complex number, then $(x_1, y_1)+(x_2, y_2)=(x_1+x_2, y_1+y_2)$,

iii) if (x, y) is a complex number, then $|(x, y)| = \sqrt{x^2+y^2}$, and

iv) if c is a real number, and (x, y) is a complex number, then $c(x, y)=(cx, cy)$

we have the following theorem.

Theorem: Suppose $\cdot$ is a relation between the terms of the ordered pairs of complex numbers such that if u is a complex number and v is a complex number, then $u \cdot v$ is a complex number. If each of u, v, w is a complex number, and x is a real number, then

i) $(x, 0) \cdot u = xu$

ii) $u \cdot v = v \cdot u$

iii) $u \cdot (v+w) = u \cdot v + u \cdot w$

iv) $|u \cdot v| = |u|\,|v|$

implies that if (x_1, y_1) is a complex number, and (x_2, y_2) is a complex number, then

$$(x_1, y_1) \cdot (x_2, y_2) = (x_1x_2 - y_1y_2,\ x_1y_2 + x_2y_1).$$

If (x_1, y_1) is a complex number, and (x_2, y_2) is a complex number, then

$$\begin{aligned}(x_1, y_1) \cdot (x_2, y_2) &= [(x_1, 0)+(0, y_1)] \cdot (x_2, y_2)\\ &= (x_1, 0) \cdot (x_2, y_2) + (0, y_1) \cdot (x_2, y_2)\\ &= (x_1x_2, x_1y_2) + (0, y_1) \cdot [(x_2, 0)+(0, y_2)]\\ &= (x_1x_2, x_1y_2) + (0, x_2y_1) + (0, y_1) \cdot (0, y_2)\\ &\ (x_1x_2, x_1y_2+x_2y_1) + (0, y_1) \cdot (0, y_2).\end{aligned}$$

Now suppose

$$(0, y_1) \cdot (0, y_2) = (z, w),$$

then

$$\begin{aligned}[\,|(0, y_1)|\ |(0, y_2)|\,]^2 &= |(z, w)|^2\\ y_1^2y_2^2 &= z^2+w^2.\end{aligned}$$

Also

$$\begin{aligned}(0, y_1)+(0, y_1) \cdot (0, y_1) = (0, y_1)+(z, w) &= (z, w+y_1)\\ |(z, w+y_1)|^2 &= |(0, y_1)+(0, y_1) \cdot (0, y_2)|^2\end{aligned}$$

$$\leqq [\,|(0, y_1)| + |(0, y_1)\cdot(0, y_2)|\,]^{2*}$$

$$z^2+(w+y_1)^2 \leqq y_1^2+2y_1^2\,|(0, y_2)| + y_1^2y_2^2$$

$$z^2+w^2+2wy_1+y_1^2 \leqq y_1^2+2y_1^2\,|(0, y_2)| + y_1^2y_2^2.$$

But $z^2+w^2=y_1^2y_2^2$, hence $wy_1 \leqq y_1^2|(0, y_2)|$.

Now if $y_1>0$, then $w \leqq y_1|(0, y_2)|$, and since this must hold for each $y_1>0$, $(0, y_2)$, then $w \leqq 0$. If $y_1<0$, then $w \geqq y_1|(0, y_2)|$ and since this must hold for each $y_1<0$, $(0, y_2)$, then $w \geqq 0$. Therefore if $y_1 \neq 0$, then $w=0$. If $y_1=0$, then since

$$(0, y_1)\cdot(0, y_2)=(0, 0)\cdot(0, y_2)=(z, w)=(0, 0),\ w=0.$$

Therefore $z^2=y_1^2y_2^2$ and hence either $z=y_1y_2$ or $z=-y_1y_2$. Suppose that $z=y_1y_2$, then

$$(x_1, y_1)\cdot(x_2, y_2)=(x_1x_2,\ x_1y_2+x_2y_1)+(z, w)$$

$$=(x_1x_2+z,\ x_1y_2+x_2y_1) \text{ since } w=0$$

$$|(x_1, y_1)\cdot(x_2, y_2)|^2 = |(x_1x_2+y_1y_2,\ x_1y_2+x_2y_1)|^2$$

$$(x_1^2+y_1^2)(x_2^2+y_2^2)=(x_1x_2+y_1y_2)^2+(x_1y_2+x_2y_1)^2$$

$$x_1^2x_2^2+x_1^2y_2^2+y_1^2x_2^2+y_1^2y_2^2=x_1^2x_2^2+2x_1x_2y_1y_2+y_1^2y_2^2+x_1^2y_2^2$$

$$+2x_1y_2x_2y_1+x_2^2y_1^2$$

$$0=4x_1x_2y_1y_2.$$

But this equation must be true if (x_1, y_1) is a complex number, and (x_2, y_2) is a complex number. Therefore $z \neq y_1\,y_2$. Hence $z=-y_1\,y_2$.

Thus

$$(x_1, y_1)\cdot(x_2, y_2)=(x_1x_2-y_1y_2,\ x_1y_2+x_2y_1).$$

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* If u is a complex number and v is a complex number, then $|u+v| \leqq |u|+|v|$. This theorem follows from the properties of real numbers and definition iii.

ANTARCTIC GLACIERS SHOW LITTLE CHANGE IN 46 YEARS

Comparison of the fronts of many glaciers in Antarctica with their positions as shown in photographs taken 46 years ago on Scott's last expedition reveal little or no change in this interval.

This is in sharp contrast to the movement of glacier fronts in both northern and southern temperate latitudes, where evidence both for growth and recession have been found. The Antarctic studies support the idea that glaciers there are sluggish.

Examination of glacial deposits in the McMurdo Sound region of Antarctica showed that both the outlet glaciers from the ice cap and the alpine, or mountain, glaciers not connected with the ice cap have fluctuated widely in thickness and extent. In the last million years, at least three major advances and retreats are recorded, each less extensive than the former.

Presenting Mean Effective Current in Elementary Physics Classes

Harry C. Wolfson
Bushwick High School, Brooklyn, New York

The present trend in high school and college freshman physics classes has been to include a larger portion of work involving alternating current theory so as to prepare students for later applications in electronics. As a result, it has become necessary to introduce in these courses the concept of "mean effective current" and "mean effective voltage" of an alternating current circuit.

This topic introduces two concepts that are difficult to present experimentally, and must therefore be taught analytically. These concepts are: first, the fact that "mean effective current" can be found by the "root, mean, square" method; and second, the application of this process to the sine curve in order to derive the formula:

$$I_e = \frac{\sqrt{2}}{2} I_{max} \quad \text{or} \quad I_e = .7071 I_m$$

The derivation of the formula for "mean effective current," I_e, can be introduced by the example: Find each of two equal one second current pulses through a resistance of one ohm that would have the same heating effect as a one second pulse of one ampere, followed by another one second pulse of 7 amperes.

Solution of problem:

UNKNOWN				KNOWN	
Current	Energy			Current	Energy
x	x^2			1	$1^2 = 1$
x	x^2			7	$7^2 = 49$
Total energy	$2x^2$	=			50
	x^2	=			25
	x	=			$\sqrt{25} = 5$ amp.

A second example will help the pupils grasp the principle involved: Find each of three equal one second pulses that would have the same heating effect as a one second pulse of 1 ampere, followed by another pulse of 5 amperes, and then by a third pulse of 11 amperes.

Solution of problem:

UNKNOWN		KNOWN	
Current	Energy	Current	Energy
x	x^2	1	$1^2 = 1$
x	x^2	5	$5^2 = 25$
x	x^2	11	$11^2 = 121$

Total energy	$3x^2$	=	147
	x^2	=	49
	x	=	7 amp.

After the two examples have been solved, the teacher will have no difficulty in extending the principle involved to the general case to derive the formula:

$$I_e = \sqrt{\frac{\sum i^2}{n}}$$

It is in proving that, for a sine wave form, the value of the effective currents equals .7071 times the maximum current that a difficulty of presentation becomes evident. Obviously, the calculus is too advanced for most of the high school pupils and college freshmen that study elementary physics. It is too much to expect these students to evaluate the definite integral involving the integration of $\sin^2 x dx$. Most text books avoid this difficulty by merely stating that it can be shown that the result will equal $\sqrt{2}/2$ times the maximum current. This approach seems too much like presenting a recipe for the answer, and tends to deny the chief purpose of science teaching.

Using the purely statistical approach is an improvement, but seems so laborious as to tend to hide the result in the mass of numerical computation. Furthermore, the student would expect such a result to be an approximation that would approach the correct value only when the number of divisions is increased without limit. An example of this method is given below:

Interval	Mid-value x	Instantaneous value of current $I_m \sin x$	Current squared $I_m^2 \sin^2 x$
0– 30°	15°	$.259I_m$	$.0671I_m^2$
30– 60°	45°	$.707I_m$	$.4998I_m^2$
60– 90°	75°	$.966I_m$	$.9332I_m^2$
90–120°	105°	$.966I_m$	$.9332I_m^2$
120–150°	135°	$.707I_m$	$.4998I_m^2$
150–180°	165°	$.259I_m$	$.0671I_m^2$

Sum of squares of current $= 2.9982I_m^2$
Average of sum of Squares $= .4997I_m^2$
Square root of average $= .707I_m$

A simple variation of this method can be used to eliminate all of the laborious computation, to correlate the work with the simple high school trigonometry that all of the students should know, and at the same time introduce a rigorously correct result.

The suggested method follows:

The symmetry of the sine curve shows that the effective current

is the same from 0 to $\frac{1}{2}\pi$, as for the entire curve. Over this range we start the presentation as though we were going to find the square root of the mean of the squares as above, but DO NOT USE THE TABLE OF VALUES:

Interval	Mid-value x	Instantaneous value of current $I_m \sin x$	Current squared $I_m^2 \sin^2 x$
0–30°	15°	$I_m \sin 15$	$I_m^2 \sin^2 15$
30–60°	45°	$I_m \sin 45$	$I_m^2 \sin^2 45$
60–90°	75°	$I_m \sin 75$	$I_m^2 \sin^2 75$

Sum of squares of current $= I_m^2(\sin^2 15 + \sin^2 75 + \sin^2 45)$

Since: $\sin 75° = \cos 15°$; and $\sin^2 15° + \cos^2 15° = 1$, and $\sin 45° = \sqrt{2}/2$ making $\sin^2 45° = \frac{1}{2}$, then the sum of the squares of the current equals $1\frac{1}{2} I_m^2$. When we divide this sum by the number of cases used, we get for the value of the mean effective current:

$$I_e = \frac{\sqrt{2}}{2} I_m, \quad \text{or} \quad I_e = .7071 I_m.$$

So far this seems to be a trick that, because of a choice of special values for the angles happens to produce the exact results for the mean effective current. However, no matter how small these intervals may be made, the sum of the squares will always consist of pairs of values of $\sin^2 x$ and $\sin^2 (90° - x)$ with $\sin^2 45°$ at the mid-interval. Since $\sin^2 x + \sin^2 (90° - x) = 1$; the sum of the squares of the current must always equal $n/2\ I_m^2$, and the average of the square of the current will always be equal to $\frac{1}{2} I_m^2$. By using the theory of limits we can make the derivation mathematically rigorous, though the use of mathematical notation might be beyond the scope of the students' preparation.

This method of deriving the mean effective current has the advantage of showing the reason for the use of the constant (.7071) while using an approach that is basic in the application of mathematics to science.

RADIATION SLOWS DOWN AGING IN DOGS

Aging is a disease that small doses of radiation may slow down, at least in dogs.

Very low levels of radiation in some cases seem to cause blood changes that enable the test animals to ward off microbial diseases more effectively. The white blood count in these cases rises, thus enhancing the body's natural defenses against disease.

Why Didn't They Tell Me?

Cecil B. Read
Mathematics Editor

SCHOOL SCIENCE AND MATHEMATICS again presents one of its series of letters written by a secondary school teacher in the first or second year of teaching, presenting some of the points of view that might have been a part of his undergraduate preparation for the teaching profession. As might be expected various teachers have differing problems and sometimes even have differing points of view on the same problem.

Dear Professor:

Many times since I have been teaching, I have made the remark to my roommate, "My second year of teaching will be richer far because of the experiences I have had this year." This will be true because each day of school teaches me something that I had not previously known. As I began to think about this, I wondered just why I had not known some of these things. Was it because I had failed to apply my learning to them, or was it because I had never learned them?

For example, on the first day of school I had planned exactly what I was going to say to each class. But when I got before the class, my memory failed. And so I just talked. I talked of procedures, methods, and of what I expected from the students and what they could expect from me. But I really didn't know what I expected from them. Nor did I know actually what they could expect from me. Telling them little things that seemed so insignificant on that first day of school would have helped me to be a better teacher. Through the months, I feel I have compensated somewhat for this, for as my experience grew, my methods changed. I do feel, however, that my teaching would have been much more effective had I better known how to "establish" myself on that first day.

One of my greatest problems during the first few days of school was my grading system. I could not decide whether it would be better to grade on the curve or on the percentage basis. I finally decided on the latter.

Why weren't we, when we were in training to become teachers, taught how to begin the school year?

We were taught methods. We were taught facts. We were taught how to psychologically handle the children. But why weren't we taught how to orientate ourselves with our classes? We were told how to introduce ourselves to our classes and how to proceed directly with the lesson. But in student teaching, the critic teacher has the class well under control before a student teacher ever enters the room. The student teacher has no real authority over the students so how is she supposed to know how to execute that authority in her own classroom?

In Methods class, we were taught to teach by discovery rather than by rule. This, I believe, is easier said than done. I knew youngsters were very inquisitive, but I certainly never realized that they would ask "why" every time you taught them something new. And so very many times they ask, "Why take Algebra?" I tell them several good reasons and give practical examples and applications to daily problems, and two days later, they ask the same question again.

One thing that really surprised me was the interest that my students have shown in the history of mathematics. When we studied linear measures, we talked at some length on the history of each of the measures. My students loved it. I now try to bring some history of math into each new topic. It fascinates my students and stimulates them toward more eager learning.

I feel that I still have much to learn. But I learned a great deal when I followed the advice of one of my college instructors. It was simply, "Never try to bluff a student. If you don't know, tell him so."

I have often asked myself, "Why didn't they tell me?" Yet I realize that some things you just can't be told. You have to learn them for yourself. Nothing can take the place of experience.

LENORA HILL
Jr. High School
Freeport, Illinois

Dear Sir:

Quite a lot of time has passed since I last sat in one of your classes, and I have really been getting some delightful and other experiences in the teaching field. I have junior high school students, and I am very glad of it. They are grown up enough so you can treat them about the same as an adult, and yet they have all the spirit and enthusiasm of children. I am very happy with my choice of age level.

One of my biggest shocks on our public school system was this fact—"I simply did not know there were so many dull normal children in our schools." It just takes miles and miles of patience to get even the simple process of problems across to some students. I believe if I needed any kind of course, it would be entitled "How to improve your patience." Of course I am teaching in a small town, and the only division my students have is the alphabet, so I have slow, fast, and average students all wrapped up in one class. My only classes with a different division is the 9th grade algebra and general mathematics course. Even in these, if parents wanted their children in algebra, they got to take it. So as you can see, I have to really direct my teaching to the average student, if there is such.

Do you remember how I always wondered what I would do with the bright child? Well, I have discovered that he isn't my biggest headache. Bright children will work on projects on their own if they have any spare time, and fortunately for me anyway, my superior students love to do extra work. But it is poor little "Johnnie" with an intelligence quotient of 80 and a "personality quotient" of about 130 that really breaks your heart. I've really had to discover ways of teaching to this type of student, and I am at school before and after to give help if the pupils want it. I never force any pupil to stay for extra help, because I believe the desire to learn must come from them first. Why wasn't I familiar with this little "Johnnie" when I was in school? Certainly they must have been there. Is it just that now I am teaching, I am paying more attention to other people? Is it that most teachers come from the above average group and are usually divided into classes, so they never have attended classes with the slower students? Is it a combination or a variety of things?

I sincerely hope that more students would learn about "Johnnie" before going out to teach, so the possibility of discouragement would be slight among new teachers. Maybe this is because I am working with junior high level and not older students, but I think I could have prospered more if I would have taken more method courses in college. Even though you never have children like the books' examples, you do collect helpful material on different methods of teaching a concept. Also I believe it would help if the college professors who teach methods courses would not limit their teaching to just college students. When this happens, they are used to only the above average class of students, and are not familiar with the typical teen-ager in a mathematics class.

I would suggest to all students who are definitely going into the teaching profession to take as much student teaching as they can. I am so glad I had my full year of student teaching before going out on my own. I really believe it was my most valuable course in college.

Well, Sir, after nearly one year of teaching, I am still very pleased with my profession, for I do just have a wonderful time with my students. Discipline is no problem at all. I better close though, and get some of my papers graded!

EVA IRENE KEIL
Lacon, Illinois

The Meaning of Science and Technology in Western Civilization*

Carl F. Klocksin
Milwaukee, Wisconsin

Part I. Science, Technology, and the Industrial Revolution

The terms science, technology, and the industrial revolution have a special magical appeal to the general public, to those especially who had little scientific training. Formerly, in past cultures and civilizations, the medicine man and the shamin received public veneration and deification. For centuries shamins supplicated the evil forces of nature, and made her serve man's ends, and for this they received separate veneration, and the reverent adoration of the men who labored in the fields, and toiled in the small shops of every great city.

But today, all this has suddenly changed. The public worship of mystical powers has been somewhat less magically transferred to scientists, engineers, and great industrialists. Science and its applied technologies have the same office to perform today as natural philosophy in nineteenth century Europe. They are, indeed, the sumum bonum of modern European civilization. But, it is only proper here to inquire how this vast change has come about, how it has transpired, and who were its chief architects and planners, for admittedly, if we permit the principle of causality to operate in nature, all great events are positively caused. The answer is rather trite and simple. Science and technology caused the Industrial Revolution, and the Industrial Revolution is the very heart and locus of western civilization. May I also state here, that it is still happening. It is not historic in that sense, it is still actively going on: so long as science and technology flourish, the industrial revolution will always be an active, changing process. For the idea that is pertinent here is that science changes, and that as it changes, technology changes, and with it, the whole fabric of our industrial society. Religions, philosophies, magical rites in Oceania and Australia, mathematics and logic, are unchanging and historic in time and in space; but physical science and its allied technologies are not mere physical constants in nature; they themselves are constantly changing, and they in their turn effect vital changes in man's sociological activities.

Thus, the presumption that society changes, that social change as a process defines sociology, is primarily based, first of all, upon the essential and inherent changeability of physics and its applications,

* A paper presented at the Convention of the American Association for the Advancement of Science, Indianapolis, Indiana, December 28, 1957.

the various engineerings, mechanical, electrical, chemical. In physics, the mechanics of Newton has been replaced by the relativistic mechanics of Einstein; in engineering, the steam engine has been succeeded by the Diesel-electric as a basic unit of power. The point most pertinent here is that there are no changeless, immutable, eternal ideas or events in physical nature, in applied science, or in society itself. Indeed, the whole idea of progress rests solidly upon the immutable fact that change is the constant fact of physical and social nature.

If then, there are no eternal principles, no immutable laws, no preordained results, always certain to follow, in physics, technology and sociology, how, then, does one explain the vast prevalence of these static ideas in the world of learning today? The answer probably lies in the fact of the fixed and unchanging biological nature of man. For in all truth the changeless, the eternal, the immutable, the everlasting, are all traits of man's biology, which has remained unchanged for over 100,000 years on this earth's ribald surface. For in simple honesty, the human body and its concomitant organ systems have not perceptibly evolved or changed for the entire sweep of human history. The unchangeable point of reference, hence, is obviously the human organism.

Man's brain, his basal ganglia, his cerebrum, cerebral cortex, hypothalamus, in effect, his central and autonomic nervous systems, have not altered or changed or progressed in any evolutionary sense for well over 100,000 years. We have to antidate human history by thousands of years to trace, as anthropologists have done, the anatomic differentiation of man from the lower primates. Thus, the point that emerges from all this array of nature is that nature is the real physical constant of natural science: any social science which rejects the biology of man is weak stuff indeed. And from this it obviously follows that cultural phenomena change, human institutions change, science itself changes, the revised technology of today is not the technology of yesterday, change and variation are the essences of all societal life, but human biology is the haven of the eternal and changeless human nature.

Part II. Science, Technology, Theory and Practice

Thus far in our paper we have spoken of science and technology as being more or less one aspect of one process, but actually there is, so to speak, a perverse bill of divorcement between them. Science, briefly put, is the theoretical investigation of physical and social nature by the special use of a new method of inquiry: the method of observation, experimentation, and verification of all natural and social phenomena. Science, thus, is a very particular kind of natural

knowledge. But we define it, not by its content, but by its unique methods. Physics becomes the most perfect, the most intelligible natural science. Sociology becomes likewise, the most nearly perfect social science. The pure scientist has as his main interest research into the secrets of physical and social nature. Technology, on the other hand, can be partially defined as applied science. The technologist's aim is practical, pragmatic and empiric: he is most certainly not interested in pure research as an end in view; rather, his purposes are easily satisfied when a new house or factory or engine is designed, constructed, and put into effective use. The engineerings are unique and favorite applications of physics: witness, for example, the extension of Mechanics into Mechanical Engineering; of Electricity and Magnetism into Electrical Engineering; of Thermodynamics into Heating and Ventilating Engineering. The private and public concern of technology is pragmatic: The workability of a given chemical process, mechanical invention or machine design is what really counts with the Engineer. Thus, the essential difference between science and technology rests in their separate aims: Physics investigates the natural world to divest it of the secrets of nature; Engineering applies the laws of Physics to directly change and transform the physical world.

Part III. Science, Technology, and Health

When we discuss health, we trespass upon commonly sacrosanct ground, an area of human experience usually reserved for the pompous giants of materia medica. But most of us are not physicians; moreover, the vast majority of us lack any special training in human biology, in anatomy, physiology or biological chemistry. Without even a semblance of factual knowledge of natural man, without even a common knowledge of himself, the average man is apt to defer to physicians, to frequent their offices, to purchase special pills, all because of the simple fact that modern education neglects the biology of man: it reserves the special study of Human Biology to Schools of Medicine, and so effectively severs from the mass of men any connection with their biological selves. The biological sciences upon which clinical medicine is based—anatomy, physiology, biochemistry, endocrinology, higher vertebrate zoology, are all but omitted in the average curricula of a college of liberal arts: what is worse, the high schools, which could teach human biology, dote upon plant anatomy, a spurious, museum-like biology. A knowledge of good health is one of the cardinal principles of education, but how can we possibly achieve this end by neglecting the study of human biology on secondary, college, and graduate school levels?

To a certain extent, Medicine is a technology, an applied science.

Indeed clinical medicine is based upon the pure sciences of anatomy, physiology, and biochemistry. But a knowledge of human biology should not, need not, be the exclusive pre-occupation of a closed social group, restrictive and narrow in its societal obligation, i.e., physicians and surgeons. Biological knowledge belongs to all mankind. It certainly belongs to public education. We should not be so evil and narrow as to restrict it to one professional group of men, that is, to physicians and professors of medicine in medical schools. A knowledge of human biology should belong to all men and to all races: this is the simple duty of the elementary and secondary school: to universalize human biology for the welfare of all the races of mankind.

Science, Technology, and Health enter another important area of human experience: factory and machine design. Engineering schools, like Schools of Education, neglect or eliminate the discipline of human biology in their curricula: hence engineers, like teachers, are turned out upon the world without any biologic knowledge of themselves. And their conscious designs indicate their common lack of biologic insight: noisy machinery in loud, noisome factories, factories designed to kill the human organism, but make a profit for the employer; large buildings designed to limit the movement of human beings in close cramped quarters. But this is not all! High school buildings designed and built to please the contractor and the architect completely out of harmony with the dignity and sancity of human life. All of this could be easily remedied with a simple request and a simple formula: integration of Schools of Medicine, Schools of Engineering and Schools of Education, so that physician, teacher, and engineer, all have a minimum of biologic and social knowledge with which to confront the complexities of western civilization.

Part IV. Science, Technology, and the Unity of the Human Being

Thus far in our paper we have presented a philosopher's appraisal of the meaning of science and technology in western civilization. Now meaning implies an analysis of ideas as well as a chronological statement of them. Thus, a physicist is interested in more than the bare summary statement of a particular physical law, such as Newton's three laws of motion, of the law of universal gravitation. He is interested in the principles which underly the whole of the philosophy of nature. Thus, Natural Science or Physics is basically interested in the principles which underly the whole of natural knowledge. This brings us face to face with one of the great and tragic events of the nineteenth century—the breakdown of Philosophy, the separation of Philosophy, of the principles of universal knowledge, into discrete and distinct specialties.

Throughout the nineteenth century Physics was everywhere known as Natural Philosophy, Psychology as Mental Philosophy, and Ethics as Moral Philosophy. Thus, there existed in Europe up to the end of the nineteenth century, a relatively unified body of ideas on the place of man in nature, on the unity of the human psyche. This gave to the Victorian Age a unified view of the moral and physical universe, similar, in fact, to the spiritual unity of the medieval world of Aristotle, Plato, and Aquinas.

Therefore, this unity of the natural, mental, and moral universe gave to nineteenth century man a spiritual unity of mind and body—a monistic sense of security in an outwardly pluralistic universe, a sense of security and peace of mind—he had little need of psychiatry to assure him of the reasonableness of existence.

The breakdown of the unity of Philosophy, of Natural Philosophy into Physics, Chemistry and Biology; of Mental Philosophy into the Social Sciences, and Moral Philosophy into the Humanities, accentuated the devisive spirit of the human psyche, and resulted in the extreme academic specialism of the modern twentieth century, both within and without the great universities.

Thus, Victorian Man had three unified philosophies of nature with which to face the future unafraid, and not too lonely—Natural Philosophy or Physics, Mental Philosophy or Psychology, and Moral Philosophy or Ethics. This, modern man surely does not have. For we have fragmentized modern human knowledge to such an extent with the extreme vice of specialism that we have indeed lost the unity of the human psyche amid the chaos of the modern world.

Now, what is the remedy for all this, what specific steps can we take to restore the Medieval and Victorian views of man in the moral universe? Several forward steps can now be taken, practical I suspect, and not too shadowy or evasive:

(1) We can reorganize the great state and private universities in the following manner:

Three great faculties, each with a separate Graduate Dean, can be established, completely diseparate from the professional schools of law, medicine, and engineering, thus:

The Graduate Faculty of Natural Philosophy (Physical Sciences and Biological Sciences). The Graduate Faculty of Mental Philosophy (The Social Sciences). The Graduate Faculty of Moral Philosophy or The Humanities.

(2) We can organize and establish Institutes of Human Biology to devote themselves exclusively to the applications of Genetics to the social sciences.

(3) The serious study of Human Biology should take its proper place in the curricula of secondary schools, colleges, and universities.

(4) Secondary Education should be entirely and thoroughly reorganized in the following manner:

(a) The term Social Studies and the term General Science should be excluded from the high school—instead Physical and Social Science should be used.

(b) Homogeneous grouping should replace Heterogeneous grouping.

(c) Special facilities should be established for the gifted student.

(d) We should drastically eliminate from secondary education all unnecessary extracurricular activities.

(e) The philosophy of Secondary Education should be carefully restated and re-defined in the following way: Education should consist, first of all, in cultivation of the intellect, personality, behavior, and character development to be considered subsidiary goals in the educational process. Thus, the educational process should consist first, in the cultivation of the intellect, and second, in the development of a harmonious personality, emotionally stable, and of sound character.

METEORITE CRATERS MAY ONCE HAVE COVERED EARTH

Recent aerial photographs have disclosed a number of huge meteorite craters on earth, one in Canada measuring some 20 miles in diameter according to C. S. Beals, director of the Dominion Observatory at Ottawa. Evidence is thus accumulating in support of the view that the earth's land masses may once have been as heavily scarred by meteorite pits as the face of the moon is today.

"The first meteorite crater on earth to be established as such," said Dr. Beals this week, "is the great Barringer crater in the Arizona desert. From a distance it looks like a low, gray mesa, conspicuous against the reddish plain. Its gentle outer slopes are littered with sand, broken rock and angular blocks of limestone. Upon climbing to the top, visitors are astonished by what they see: a tremendous bowl, three quarters of a mile across and more than 600 feet deep, ringed by a steeply slanting wall sown with more fragments of rock. Even to a nongeologist the crater seems clearly to have been blasted out of the layers of limestone and sandstone whose contrasting strata encircle it. Conclusive evidence of the origin of this crater is the fragments of the meteorite itself. These lumps of nickel-iron and iron oxide, found in abundance in and around the crater, range in weight from a fraction of an ounce to more than half a ton. The age of the Barringer crater has been estimated at 50,000 years. It has weathered little in the dry, stable climate of the region.

"Some 20 similar craters and clusters of craters of recent age have since been found scattered across the continents. The largest of them, the great Chubb crater in the northern wilderness of Quebec, is more than two miles in diameter and a quarter mile deep. The smallest measures a few dozen yards across and a few yards deep. The most recent fall occurred in 1947 only a few hundred miles from Vladivostok. Soviet scientists have found many meteorites scattered around its numerous well-marked craters.

LOW OXYGEN SUPPLY FORCES DEATH UPON CANCER CELLS

Suffocation of tumor cells by means of lowered oxygen supplies in patient's rooms may become a possible cancer treatment, a Columbia University professor of biochemistry reported.

Mice experiments have shown that some types of tumors can be inhibited by oxygen starvation of cancer cells after the animals' bodies become accustomed to the low oxygen supply.

The theory proposes that cancer cells are unable to adjust to reduced oxygen supplies as do the normal cells that simply stop the normal growth process. Since oxygen is essential for growth, cancer cells must grow or die.

Normal cells can adjust to a reduced supply of oxygen, maintaining themselves, but not growing. Cancer cells, under these same conditions, cannot grow, so they die.

Coefficients in Expansions of Polynomials

D. Mazkewitsch

University of Cincinnati, Cincinnati 21, Ohio

I. Polynominals in which the Exponents of the Literal Factor Form an Arithmetic Progression

a) *Polynominals with arbitrary coefficients.*

Take for instance

$$(a+bx+cx^2)^3=(a+bx+cx^2)(a+bx+cx^2)^2,$$

expand the square and carry out the multiplication:

$$\begin{array}{l}
(a+bx+cx^2)^3=(a+bx+cx^2)\left|\, a^2+2abx+(2ac+b^2)x^2+2bcx^3+c^2x^4 \right| \\
=a^3+2a^2bx+(2a^2c+ab^2)x^2+2abcx^3 \qquad +ac^2x^4 \\
\qquad +ba^2x+2ab^2x^2 \qquad +(2abc+b^3)x^3+2b^2cx^4 \qquad +bc^2x^5 \\
\qquad\qquad +ac^2x^2 \qquad +2abcx^3 \qquad +(2ac^2+b^2c)x^4+2bc^2x^5+c^3x^6 \\
\hline
a^3+3a^2bx+(3ab^2+3a^2c)x^2+(6abc+b^3)x^3+(3ac^2+3b^2c)x^4+3bc^2x^5+c^3x^6. \\
1 \qquad 2 \qquad\qquad 3 \qquad\qquad\qquad 4 \qquad\qquad\qquad 5 \qquad\qquad 6 \qquad 7
\end{array}$$

Read the columns, each of which contains three terms, upward: In the first column the two first terms are absent, we may consider them as zeros. In the second column the first term is zero; ba^2x is the product of a^2 by bx, and $2a^2bx$ is the product of $2abx$ by a. In the third column, which like the 4th and the 5th, contains all three terms, a^2cx^2 is the product of a^2 by cx^2, $2ab^2x^2$ is the product of $2abx$ by bx, and $(2a^2c+ab^2)x^2$ is the product of $(2ac+b^2)x^2$ by a. Similarly are built the next two columns, namely: while the terms of the second parenthesis are taken in progressive order, those of the first parenthesis are taken in reversed order. In the 6th column the terms are the products of $2bcx^3$ by cx^2 and of c^2x^4 by bx. In the 7th column: c^2x^4 by cx^2.

From columns 3 to 5 we see that the three terms of each column represent the products of three consecutive terms of the second parenthesis (the sets beginning with the 1st, 2nd and 3rd term respectively) multiplied respectively by the terms of the first parenthesis taken in reversed order.

The above observations suggest the following writing and procedure for obtaining the expansion

$$\begin{array}{ll}
(a+bx+cx^2)^3 & \\
=(0+0+a^2+2abx+(2ac+b^2)x^2+2bcx^3+c^2x^4)(cx^2+bx+a) & \\
=0\cdot cx^2+0\cdot bx+a^2\cdot a & =a^3 \\
+0\cdot cx^2+a^2\cdot bx+2abx\cdot a & =3a^2bx \\
+a^2\cdot cx^2+2abx\cdot bx+(2ac+b^2)x^2\cdot a & =(3ab^2+3a^2c)x^2 \\
+2abx\cdot cx^2+(2ac+b^2)x^2\cdot bx+2bcx^3\cdot a & =(6abc+b^3)x^3
\end{array}$$

$$
\begin{array}{ll}
+(2ac+b^2)x^2\cdot cx^2+2bcx^3\cdot bx+c^2x^4\cdot a & =(3ac^2+3b^2c)x^4 \\
+2bcx^3\cdot cx^2+c^2x^4\cdot bx & =3bc^2x^5 \\
+c^2x^4\cdot cx^2 & =c^3x^6 \\
\hline
\multicolumn{2}{l}{a^3+3a^2bx+(3ab^2+3a^2c)x^2+(6abc+b^3)x^3+(3ac^2+3b^2c)x^4+3bc^2x^5+c^3x^6.}
\end{array}
$$

Consider now

$$(a+bx^n+cx^{2n}+dx^{3n}+\cdots kx^{pn})^m,$$

where $m=0, 1, 2, 3 \cdots$; $n, a, b, c, \cdots =$any number, positive or negative, integer or fractional; p finite. Expanding for a definite n and p the respective polynomial, in the above indicated manner, for $m=0, 1, 2, 3, \cdots$, we can arrange the coefficients of the expansions in a triangular form. However, to write down the triangle, it is not necessary to carry out the multiplications.

We note the following: The exponents of the above polynomial form an arithmetic progression $n, 2n, 3n \cdots, pn$ with the difference n; the exponents of the expansion form also an arithmetic progression: $n, 2n, 3n \cdots, pnm$ with the same difference n. The coefficients of the expansion for a given m remaining the same for any n, we shall consider in what follows progressions with $n=1$. The coefficients of x^i in the expansion $(a+bx+cx^2+ \underset{i}{\cdots} kx^p)^m$ and of x^{pm-i} in the expansion

$$(ax^p+bx^{p-1}+\cdots+k)^m$$

are identical. To establish the law of formation of the coefficients we have to distinguish two cases.

1. *np is even, i.e. the number of terms in the polynomial is odd*

For example,

$$(3+2x+x^2+3x^3+2x^4)^m$$

We remark that the expansions of this polynomial to the powers $0, 1, 2, 3 \cdots$ contain respectively $1, 5, 9, 13 \cdots$ terms. In general, the expansions of a polynomial with an odd number of terms contain an odd number of terms. Hence we write

				0	0	0	0	1						
		0	0	0	0	3	2	1	3	2				
0	0	0	0	9	12	10	22	25	14	13	12	4		
		27	54	63	125	183	168	178	195	141	87	66	36	8
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

The triangle is obtained in the following way. Write 1 and to the left of it four zeros (number of terms in the polynomial minus 1). The first figure in the next row, second, is placed under the second zero left of 1 (number of terms in the polynomial minus the rounded off half of it; in this case $5-3$). It is obtained by multiplying five consecutive numbers of the row above respectively with the coefficients

of the given polynomial in reversed order, starting with the first zero on the left, and adding them. The next number is obtained in the same way by starting with the second zero. Thus $0.2+0.3+0.1+1.3=3$; $0.2+0.3+0.1+1.2=2$ etc. Now write left of 3 again four zeros. Under the second zero left of 3 is placed the first number of the next, third, row. The numbers are obtained as before. Thus

$$0.2+0.3+0.1+0.2+3.3=9,\ 0.2+0.3+0.1+3.2+2.3$$
$$=12\cdots,\ 3.2+2.3+1.1+3.2+2.3=25,\cdots,\ 3.2+2.3=12,\ 2.2=4.$$

The next, fourth, row is obtained in the same way. Note: The place of any number in its row is the same as the place in the row above of the first of the five consecutive numbers forming the number in question. Thus in the fourth row

$$178=10.2+22.3+25.1+14.2+13.3.$$

178 is the 7th number, and 10 is the 7th number, counted from the first zero, in the 3rd row.

This permits an easy check of any number.[1]

2. *np is odd, i.e. the number of terms in the polynomial is even.*

For example,

$$(2+x+2x^2+3x^3)^m.$$

We remark here that the expansions of this polynomial to the powers 0, 1, 2, 3 $\cdots$ contain respectively, 1, 4, 7, 10 $\cdots$ terms. In general, the expansions of a polynomial with an even number of terms contain alternately an odd and an even number of terms, depending on the exponent of the polynomial; the difference between the odd and even number of terms is equal to the number of terms in the polynomial minus 1.

The procedure is exactly the same as under 1. with this difference: If the respective m is odd the expansion has an even number of terms, then the first number is placed under the second zero left to the first significant number of the line above (number of terms in the polynomial minus half of it). If m is even, then under the first zero (number of terms minus (half of it+1)).

					0	0	0	1						
			0	0	0	2	1		2	3				
		0	0	0	4	4	9	16	10	12	9			
0	0	0	8	12	30	61	66		93	98	63	54	27	
		16	32	88	200	289	464	604	608	646	528	324	216	81

. . . .

[1] In this triangle, as well as in the following triangles, the coefficients of equal powers lie on parallels to the left side of the isosceles triangle.

As an application of the above we show the expansions of a

b) *Polynomial with coefficients 1.*

$$(1+x+x^2+x^3+x^4)^m$$

						0	0	0	0	1								
				0	0	0	0	1	1	1	1	1						
		0	0	0	0	1	2	3	4	5	4	3	2	1				
0	0	0	0	1	3	6	10	15	18	19	18	15	10	6	3	1		
		1	4	10	20	35	52	68	80	85	80	68	52	35	20	10	4	1
. . .																		. . .

Here is $20=0+1+3+6+10$, 80 to the right of 85:

$$18+19+18+15+10.$$

The coefficients are symmetric.

c) *Polynomial with symmetric coefficients.*

$$(1+2x+2x^2+x^3)^m$$

					0	0	0	1						
			0	0	0	1	2		2	1				
		0	0	0	1	4	8	10	8	4	1			
0	0	0	1	6	18	35	48		48	35	18	6	1	
		1	8	32	84	160	232	262	232	160	84	32	8	1
. . .														. . .

The coefficients are again symmetric.

In all cases holds the rule: If the signs of the terms in the polynomial are alternating, then the coefficients have also alternating signs.

The above triangles may be used to find the coefficient of any power of x: Determine the place of the power of x in the development, which is the exponent $+1$. Compute in the above lying rows only those numbers which contribute to the formation of the respective coefficient. For instance, find the coefficient of x^4 in $(1+2x+3x^2)^5$

				0	0	1		
			0	0	1	2	3	
		0	0	1	4	10	12	9
	0	0	1	6	21	44	63	
0	0	1	·	36	104	214		
	1	·	·	·	530			

II. Polynomials in which the Exponents of the Literal Part Are Arbitrary

For instance

$$(1+2x^2+x^5+3x^6)^m.$$

We consider the missing powers as having the coefficient zero, and write

$$(1+0\cdot x+2x^2+0\cdot x^3+0\cdot x^4+x^5+3x^6)^m.$$

We have then a polynomial with an odd number of terms. Proceeding as sub. I 1., we obtain easily

```
                0  0 0  0  0  0  1
          0 0 0 0  0 0  1  0  2  0  0  1  3
    0 0 0 0 0 0 1  0 4  0  4  2  6  4 12  0  1  6 9
          1 0 6 0 12 3 17 12 36 12 39 18 33 36 54 1 9 27 27
 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

The zeros indicate that the corresponding power of x is missing. Thus

$$(1+2x^2+x^5+3x^6)^3=1+6x^2+12x^4+3x^5+17x^6+12x^7+36x^8+12x^9$$
$$+39x^{10}+18x^{11}+33x^{12}+36x^{13}+54x^{14}+x^{15}+9x^{16}+27x^{17}+27x^{18}.$$

Evidently, what has been said in I. c) concerning the coefficient of any power of x holds here too.

The procedure presented above enables us to write the expansion of a polynomial to the power $m+1$, when the expansion of the same polynomial to the power m is known, without performing the operation of multiplication.

It enables us also to multiply two polynomials, without performing the operation of multiplication, and without establishing a recurrence formula: write one polynomial as given and to the left of the first term as many zeros, as there are terms in the second polynomial minus 1; write the second polynomial in reversed order and proceed as indicated above.

For instance, multiply $a_0+a_1x+a_2x^2+a_3x^3$ and $b_0+b_1x+b_2x^2$.

$$(0+0+a_0+a_1x+a_2x^2+a_3x^3)(b_2x^2+b_1x+b_0)$$
$$=a_0b_0+(a_0b_1+a_1b_0)x+(a_0b_2+a_1b_1+a_2b_0)x^2+\cdots+a_3b_2x^5.$$

The operation is made easier in the following way: write the coefficients of the second polynomial, in reversed order, on a strip of paper; place the last term of the strip above the first term of the first polynomial, then displace the strip each time by one term to the right.

In order to find the expansion of a polynomial to a desired power, it is not necessary to find the intermediate expansions. For instance, find

$$P=(a_0+a_1x+a_2x^2+\cdots+a_m)^{17}.$$

Find:

$$1)\ P^2,\quad 2)\ P^3,\quad 3)\ P^5=P^3\cdot P^2,\quad 4)\ P^{10}=P^5\cdot P^5,$$
$$5)\ P^{15}=P^{10}\cdot P^5,\quad \text{and}\quad 6)\ P^{17}=P^{15}\cdot P^2.$$

III. Coefficients in Expansions of Powers of Special Trinomials

Consider $(a+bx+ax^2)^m$, and expand the trinomial for $m=0, 1, 2, 3$, as indicated in I a)1. This is sufficient to recognize the law of formation of the coefficients.

$$(a+bx+ax^2)^0=1 \tag{1}$$

$$(a+bx+ax^2)^1=a+bx+ax^2.$$

This we may write

$$a+bx+ax^2=$$

$$0\cdot b+(0+1)a+[1\cdot b+(0+0)a]x+[0\cdot b+(1+0)a]x^2 \tag{2}$$

Putting in the expansions for $(a+bx+cx^2)^2$ and $(a+bx+cx^2)^3$ $a=c$, we obtain

$$(a+bx+ax^2)^2=a^2+2abx+(b^2+2a^2)x^2+2abx^3+a^2x^4,$$

which we may write

$$\begin{aligned}(a+bx+ax^2)^2&=0\cdot b+(0+a)a+[ab+(0+b)a]x+[b\cdot b+(a+a)a]x^2\\&\quad+|\,ab+(b+0)a\,|\,x^3+|\,0\cdot b+(a+0)a\,|\,x^4\cdots\end{aligned} \tag{3}$$

$$\begin{aligned}(a+bx+ax^2)^3&=a^3+3a^2bx+(3ab^2+3a^3)x^2+(b^3+6a^2b)x^3\\&\quad+(3ab^2+3a^3)x^4+3a^2bx^5+a^3x^6,\end{aligned}$$

which we may write

$$\begin{aligned}&(a+bx+ax^2)^3\\&\quad=0\cdot b+(0+a^2)a+[a^2b+(0+2ab)a]x+[2ab\cdot b+(a^2+b^2+2a^2)a]x^2\\&\quad\quad+[(b^2+2a^2)b+(2ab+2ab)a]x^3+[2ab\cdot b+(b^2+2a^2+a^2)a]x^4\\&\quad\quad+[a^2b+(2ab+0)a]x^5+[0\cdot b+(a^2+0)a]x^6\cdots\end{aligned} \tag{4}$$

Arrange the coefficients of the expansions (1), (2), (3), (4) in form of a triangle.

$$\begin{array}{ccccccc}
 & & & 1 & & & \\
 & & 0\cdot b+(0+1)a & 1\cdot b+(0+0)a & 0\cdot b+(1+0)a & & \\
 & 0\cdot b+(0+a)a & ab+(0+b)a & b\cdot b+(a+a)a & ab+(b+0)a & 0\cdot b+(a+0)a & \\
0\cdot b+(0+a^2)a & a^2b+(0+2ab)a & 2ab & (b^2+2a^2)b & 2ab & a^2b+(2ab+0)a & 0\cdot b+(a^2+0)a \\
 & & +(a^2+b^2+2a^2)a & +(2ab+2ab)a & +(b^2+2a^2+a^2)a & &
\end{array}$$

We see that each number (coefficient) is the sum of: the number in the row above it multiplied by b and the sum of two adjacent numbers in the same row multiplied by a.

Example:

$$(2+3x+2x^2)^m:$$

$$\begin{array}{ccccccccc} & & & & 1 & & & & \\ & & & 2 & 3 & 2 & & & \\ & & 4 & 12 & 17 & 12 & 4 & & \\ & 8 & 36 & 78 & 99 & 78 & 36 & 8 & \\ 16 & 96 & 280 & 504 & 609 & 504 & 280 & 96 & 16 \end{array}$$

Here is, for instance,

$$99=17.3+(12+12)2, \qquad 504=78.3+(99+36)2 \text{ etc.}$$

It is interesting to note, that when $a=1$, $b=2$, then the coefficients in the expansion are the binomial coefficients in the expansion $(x+y)^{2m}$.

Example:

$$(1-2x^3+x^6)^4=1-8x^3+28x^6-56x^9+70x^{12}-56x^{15}+28x^{18}-8x^{21}+x^{24}$$

IV. Coefficients in Expansions of Squares of Polynomials with Coefficients 1

If we expand

$$1^2,\ (1+x^n)^2,\ (1+x^n+x^{2n})^2,\ \cdots\ (1+x^n+x^{2n}+x^{3n}+\ \cdots\ +x^{(m-1)n})^2,$$

where $n=1, 2, 3, \cdots$, and arrange the coefficients in form of a triangle, we obtain

$$\begin{array}{ccccccc} & & & 1 & & & \\ & & 1 & 2 & 1 & & \\ & 1 & 2 & 3 & 2 & 1 & \\ 1 & 2 & 3 & 4 & 3 & 2 & 1 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \end{array}$$

$$1, 2, 3, \cdots, m-1, m, m-1, \cdots, 3, 2, 1$$

The exponents of the polynomials under consideration form an arithmetic progression with the difference n. The middle coefficient in the expansion with respect to which the coefficients are symmetric, is the multiple of n of the highest exponent in the given polynomial plus 1.

This enables one to write down the square of any polynomial of the above form, without performing the operation of squaring.

Example:

$$(1+x^3+x^6+x^9+x^{12})^2=1+2x^3+3x^6+4x^9+5x^{12}+4x^{15}+3x^{18}+2x^{21}+x^{24}$$

Numerical application: Find

$$111111^2=(1.10^5+1.10^4+1.10^3+1.10^2+1.10+1).$$

Hence

$$111111^2=12345654321.$$

Should General Science Be So General?

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Too often we hear bright students complain that they have been "getting the same old stuff" in the science courses every year. This is true even in some school systems where science programs have been carefully organized from grades one through twelve. Certainly it seems odd that today, when there is so much science to teach, subject matter should be repeated and so many sciences courses should overlap.

The article, "Scope and Sequence of Elementary Science," in SCHOOL SCIENCE AND MATHEMATICS, October, 1957, pointed out that in the majority of school systems offering science programs, many broad areas of science are covered at each grade level. These basic science topics are repeated each year (or every two or three years) and as they are repeated, "more mature concepts and broader understandings are sought in each area of learning."

While this plan of organization has a number of theoretical advantages, in practice it runs into two very serious snags. First, the difference between one grade level and another is usually so hazy, even in most textbook series, that the attempt to seek progressively "more mature concepts and broader understandings in each area" is very apt to degenerate into mere repetition of each area. Second, and even more significant, the bright students will usually proceed straight to the more mature concepts and broader understandings on their first or second introduction to each area. Bright students are likely to cover in the sixth grade, for example, concepts related to living things that are theoretically supposed to be introduced in the eighth or ninth grade, or even in high school biology. Then, when these students reach the higher grades, they find themselves being taught concepts they have already mastered. If, as is often the case, classes are too large to enable the teacher to handle these students on more of an individualized basis, they become bored and discouraged.

I would like to suggest that if general science were not quite so general, this situation could be corrected, and the whole science program would be greatly improved. A number of leaders in the field of science teaching, including Dr. Hubert Evans of Teachers College, Columbia, have expressed the view that the best general science course might be a thorough investigation of *one* scientific problem or area rather than a shallow survey of many areas. Students delving more deeply into one area would be made more aware of how scientists work. They would come to realize some of the things that are involved in exploring or working in science. They would, perhaps,

understand more about the role of mathematics in science (which few students below college level understand). Much of what they would learn about the nature of one scientific problem would, of course, be applicable to other scientific problems; thus the students would also be getting a "general" introduction to science, one that would be more vital, meaningful, and interesting to them than the usual survey course is. Furthermore, repetition and overlapping would be eliminated to a great extent if we confined general science courses to single problems which are explored at length. There are so many specific topics that could be explored at length that the chances of two teachers repeating each other from one grade to the next would be lessened, especially if topics were organized throughout a school system.

Recently I handled two ninth-grade general science classes with this idea in mind. The results were most impressive. Instead of the usual survey of living things, for example, one class chose two animals for thorough study: the honey bee and the frog. All imaginable questions related to these two animals were formulated and listed by the class as a whole. Specimens, living and preserved, were observed, dissected, drawn, and compared. Investigations were launched into problems such as how these animals got food and oxygen to their cells, how they reproduced, and how they responded to their environments and were adapted. There were, of course, innumerable activities and experiments and research projects carried on by smaller groups within the class. Out of this study of particulars, many generalizations were drawn. As the discussion grew and expanded, one student was even led to set up the so-called "origin of life experiment" in which methane, ammonia, hydrogen, and water vapor flowed continually through a chamber in which electrical discharges simulated the lightning in the atmosphere some two billion years ago. (No results were obtained!)

A more significant example of this approach, one that other teachers seemed to find particularly interesting, was the way the atomic theory was introduced to one of these ninth-grade classes. For several weeks, only one molecule was studied: H_2O. The students studied its structure, the structures of its atoms, they built models, they studied the covalent bonding, the electrolysis of the compound to produce oxygen and hydrogen, and the oxidation of hydrogen to produce back the compound again. All possible questions related to this one molecule were explored. As a result, the class acquired a basic understanding of the whole atomic theory.

Another topic chosen by one of the classes was the problem of man's chances of survival in outer space, during space travel. Here again, all conceivable questions were formulated first, committees were

appointed to investigate these questions, and results were exchanged. This particular problems spread out into investigations of the needs of the human body, many of the body functions, the earth as an environment for life, the atmosphere, cosmic radiation, mutations, the solar system, and the universe.

The most interesting aspect of this approach to general science is the way each individual topic spreads out in all directions, so to speak, and gradually takes in a great many related scientific problems, concepts, and activities initiated by the students themselves. In a sense, each scientific problem is a window on all science. Students are bound to learn more about all science by delving deeply into one particular topic rather than briefly going over many general topics.

Someone once wrote that the narrowest of all specialists is the dilettante, the man who is familiar only with the surfaces of many things and who has never gone deeply into any one thing. Most junior and senior high schools are producing scientific dilettantes. We should make more of an effort to encourage students to probe deeper. This, perhaps, is true not only in science but in all school subjects.

Cutting Circular Disks

(Eighth in a Series)

Harald C. Jensen
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Circular disks cut from sheets of wood, masonite, prestwood, aluminum, copper, etc. (of thicknesses up to one-fourth inch and with diameters varying from a few inches up to about two feet) can be used in a large variety of situations on the physics lecture demonstration table. It seems worthwhile, therefore, to call attention to a simple and convenient method of cutting such disks.

The method is illustrated in figure one. The tool used is a table saw *S* fitted with an auxiliary device consisting of a piece of plywood *B* (or similar material) to which a wooden strip just fitting the groove of the saw table has been attached.

The material *M* from which the disk is to be cut is fastened to *B* at the pivot point *P* by means of a single nail driven through the center of *M* into *B*. The distance *R* between the saw blade and the pivot becomes the radius of the finished disk. While *B* and *M* are held fixed relative to each other, the assembly is pushed forward so

that a corner of M is cut off. M is then turned on the pivot so that another corner is in position to be cut off. This cutting procedure is continued until *all* corners are removed. The end result is a circular disk.

If a finished edge is desired, a piece of sand paper can then be glued to the face of the saw blade and used to sand the edge of the disk while it is rotated about P with B fixed in the optimum position. The saw blade must, of course, be rotating during the sanding operation.

This method of cutting circular disks is not new, but physics teachers interested in preparing demonstrations and exhibits seem generally unfamiliar with it. This note has been written in the hope that the trick may become more widely used.

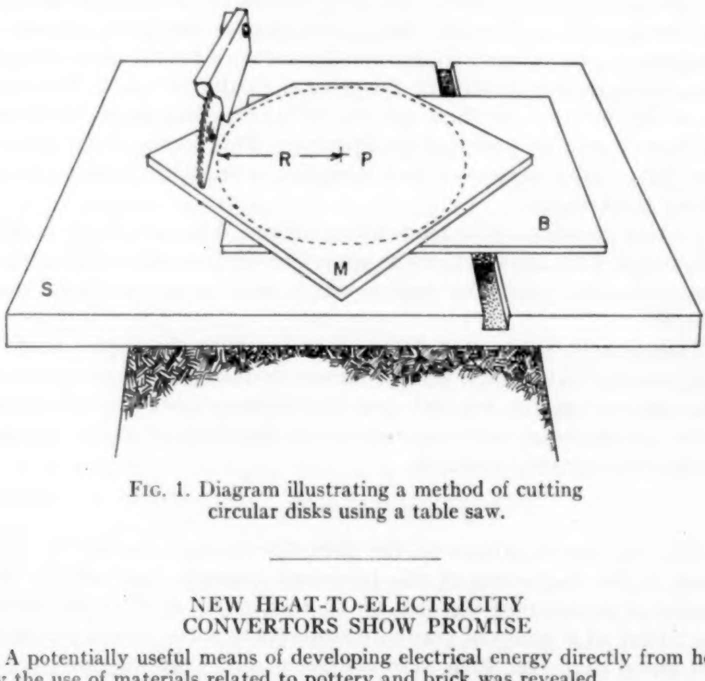

FIG. 1. Diagram illustrating a method of cutting circular disks using a table saw.

NEW HEAT-TO-ELECTRICITY CONVERTORS SHOW PROMISE

A potentially useful means of developing electrical energy directly from heat by the use of materials related to pottery and brick was revealed.

Tiny electrical power generators that do not involve moving parts nor require bulky storage batteries may be developed to operate guided missile and artificial satellite instruments, thanks to pioneering research on ceramic materials.

The materials, when heated by a flame or other high temperature source, set up an electrical current that can be harnessed for useful work.

The ceramic-like materials overcome disadvantages of earlier heat-to-electricity conversion techniques. They are common materials, compounds of metals such as nickel and manganese, and would put no burden on our stockpile of critical materials. They do not require ultra-high-purity refining, high-vacuum operation or complex electronic apparatus.

Difficulties in Algebra: A Study

G. H. Miller

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One of the aftermaths of the sputniks has been a much greater concern with the content of the curriculum in mathematics. It was a rude shock to the Americans to find that the Russians who were assumed to be backward people had a much greater emphasis on mathematics than the Americans. Detailed information on the Russian system of education can be found in several articles such as those written by the Office of Education (8) and Dewitt (5).

For years, mathematics has been considered an unpopular subject because of its difficulty. Many articles of recent origin printed in newspapers, magazines and journals have shown that students do not take mathematics because of the great difficulty involved. However no recent research on these specific difficulties has been discovered by the writer in his review of the literature. This review also indicated that few studies have ever been designed to study difficult topics in higher mathematics.

Certain questions arise from this problem. What are these specific difficulties? Can any solutions be offered to alleviate these difficulties? Are there any particular topics which need more emphasis than others?

This present study was designed to establish the topics of difficulty in algebra and offer some solutions to overcome these obstacles. The topics of algebra were selected for this investigation since algebra is the fundamental tool required for the handling of higher mathematics and scientific research.

Previous Investigations

The first investigations on the difficulty of topics in algebra were made in the beginning of the twentieth century. One of the first studies to be reported was that of Thorndike (10) in 1922. He tested the ability of a group of graduate students to solve verbal problems and found that over 40% were unable to solve correctly two out of five problems. A similar report was made by Clem and Hendershot (4) five years later. They found that only 60% of the students in the ninth grade were able to compute two out of seven written problems correctly.

Pease (9) analyzed the scores of tests given to 350 students taking first year algebra in four high schools in Iowa. He found difficulty ranges in specific items from 3% to 60% in topics which were vital for higher algebra courses. Coit (3), in a study in the Seattle School

system, found difficulty ranging from 46.6% to 64.5% for some of the simplest algebraic processes such as algebraic addition of like terms.

Another study of 280 students in five colleges in Iowa was made by Lueck (7). Students were tested on knowledge of algebra before they entered a first year physics course. Only 47% of the problems on this test were solved correctly. The topics which produced the highest failures were: solving quadratic equations by completing the square, solving a system of two equations graphically, rationalizing a fractional radical, dividing quantities involving literal exponents, solving fractional quadratic equations and simplifying an irrational radical. These topics ranged in difficulty from 68% to 93%.

Several experiments were conducted on the analysis of errors in algebra. Wattawa (12) found that most of the mistakes were made in arithmetic (35.4%) and in signs (18.7%). Arnold (1) found that 56% of the students were not able to solve 13 out of 14 problems involving fractions and least common denominator which were part of the Hotz Algebra Test.

Wren (13) surveyed the research completed before 1935 and found that students had the greatest difficulty with fractions, exponents, solving quadratic equations and simultaneous equations. Since it was evident that the students forgot two-thirds of the material which they had learned in algebra, he recommended that two years of algebra be given to the students before they attempt to take the curriculum in mathematics and science in college.

After 1935 there was very little research reported except for predictive studies of student success in algebra. Because of the influence of the research reported above, most colleges and universities required two years of algebra for admission of students who majored in mathematics and science. Hence, a study was needed to evaluate present day difficulties.

The Experiment

A survey form outlining the various topics in algebra was given to 23 classes in two universities and two junior colleges in California. These classes were a representative cross-section of students in the Southern California area; all had just completed a course in algebra or were taking other higher mathematics courses (55% were taking calculus through differential equations). Approximately 80% of the group were preparing for some profession and, therefore, these students represented a sampling of those individuals who had a considerable amount of algebra. Thus, they would be aware of their difficulties and how some of these difficulties were reduced through specific techniques of teaching.

Rating forms were given to the students by instructors in the selected schools at the end of the semester. Each student was asked to complete the form and return it the next day. This system was used to give the student enough time to reflect on the topics.

In the first section of the rating form, the student indicated his complete algebra background. There were five categories: elementary and intermediate algebra (these courses are taught primarily in the junior colleges in California), first and second year high school algebra, and college algebra.

Fifty-one topics were listed in the second section. This list included all the basic topics from elementary algebra through college algebra. These topics were selected by mathematics instructors based on the usual topics covered in algebra text-books. In this section the student was instructed to place an "X" in front of the topics which he had taken. If the subject was easy, he was to place an "E" after the "X"; if the subject caused difficulty, he was to place a "D" after the "X"; and if the topic was never mastered, he was to place an "N" after the "X". In this way only the ratings of the topics that the student took were considered.

In the third section of the rating form, the students were asked to give specific examples which caused difficulty and were requested to mention any techniques which helped to clarify these difficult topics.

Three hundred and eighty-nine (389) forms were collected and analyzed. Only the topics which were listed as difficult or never mastered were considered in this report. The three classifications of student background, which were determined from the data in the first section of the rating form, were used to check on the internal consistency of the difficulty for each topic within these three groups; i.e. elementary and intermediate algebra, first- and second-year high school algebra and college algebra.

The results of the study were reported in the form of per cent scores as computed from the number of students listing the topics as difficult or never mastered. The statistics on the three classifications of student background are not included in this report.

Since this study is based upon information obtained from a survey, it provides for an analysis of a broad coverage of topics. At the same time this survey is lacking in the definite details of difficulty within the specific topics which some other types of research would provide. The value of this study is its use in isolating and approximating the difficult topics of intermediate or second-year high school algebra and college algebra without the necessity of subjecting the students to several hours or days of extensive examinations to find out similar information.

This study is capable of providing such information as:

1. Verfication of difficulty with certain topics usually known to the experienced instructor, and an indication of other difficult topics which he may have overlooked.
2. A list of difficult topics in algebra which can serve as a guide to the new or inexperienced instructor so that he may be better prepared for those problems as they arise.
3. The specification of some of the methods used by instructors which students indicated as assisting them in overcoming their difficulties in various topics of algebra.
4. An indication of the topics to consider for more detailed research in the difficulties of algebra.

Findings

The data in the table below is listed in decreasing order of difficulty. The combined per cent score which is listed for each topic indicates the per cent of students who marked the subject as difficult or never mastered. Only these topics which had a per cent score of 35 or above were considered. The results were as follows:

Topics	*Per Cent Score*
Mathematical expectation	65.5
Permutations and combinations	62.9
Mathematical induction	62.5
Statement problems	61.8
Interpolation method for irrational roots	57.8
Probability	56.4
Newton's method for irrational roots	56.2
De Moivre's theorem	53.4
Annuities	49.9
Arithmetic and geometric progressions	49.0
Obtaining the term of a binomial expansion	48.2
Higher order determinants	47.2
Graphing of complex numbers	47.0
Solution of 3rd degree equations	46.8
Inequalities	45.2
Changing index of radicals	43.6
Principles of determinants	39.2
Binomial expansion	39.2
Compound interest	39.1
Principles of logarithms	37.0
Negative and fractional exponents	37.0
Graphing of circles, hyperbolas and ellipses	36.4
Computation of logarithms	36.3
Variation	35.4
Addition and subtraction of radicals	35.3
Multiplication and division of radicals	35.2

Conclusions

The analysis of the rating forms provided the following conclusions:

1. The topics which presented the most difficulty were those taught in college algebra or were algebra topics taught in more advanced mathematics courses. Thus, a majority of the students had difficulty or never mastered such topics as probability, permutations and combinations, mathematical expectation, state-

ment problems, computation of irrational roots, infinite series and DeMoivre's theorem.

2. Most of the topics (16 of the 26 items presented in the table) which caused difficulty were consistent within a 10% range when the different educational backgrounds were considered (elementary and intermediate, first- and second-year algebra and college algebra). Thus, the difficult topics mentioned in the earlier courses, intermediate or second-year high school algebra still persisted in the more advanced courses, such as calculus and higher algebra.
3. Many of the topics listed as difficult or never mastered involve one fundamental concept. An understanding of the exponential concept is necessary to comprehend such topics as logarithms, fundamental operations with radicals, binomial expansion, compound interest, annuities, arithmetic and geometric progressions and infinite series.
4. In response to the third section of the questionnaire where the students wrote in the specific types of problems which caused them difficulty, exponents and written problems were cited most frequently. This analysis gives additional emphasis to the difficulty of these two topics.
5. A summary of the most mentioned techniques which assisted the students in understanding the difficult topics in algebra were:
   a. The instructor provided clear, well-explained problems and used graphic illustrations where applicable.
   b. The textbook selected provided several examples of the types of problems being considered and had answers to the exercises.
   c. The instructor spent more time on each topic until it was comprehended instead of completing a list of topics in a specified period of time.
   d. The instructor provided some blackboard supervision and individual assistance when necessary.

Recommendations

After a consideration of the conclusions of the study, the following recommendations can be made:

1. The most significant trend indicated in this study was the need to provide more time in the explanation of exponents. Thus more time should be alloted for the development of the direct relationship between the laws of exponents, logarithms and radicals and also on the interrelationships of exponents with other topics such as binomial theorem and annuities.

2. Development of better teaching techniques for the most difficult topics such as the statistical topics (probability, permutations and combinations and mathematical expectation). The majority of those who go into the professions which use mathematics should not have the feeling that they do not comprehend these subjects in algebra. This is the area where research in the details of the difficulty of algebra would be valuable.
3. In cases where two or more difficult topics are taught to accomplish identical results such as the approximation of roots and the solutions of equations in many variables, the easiest method should be taught and the others eliminated from the basic aims of the course.
4. Instructors might orient their teaching techniques, if they have not done so, with some of the suggestions provided by the students on methods which helped clarify the difficult topics.
5. A study should be made to find out those topics in algebra which are vital for advanced mathematics and scientific research. A study of this type is particularly important in view of the recent trend to stress "modern mathematics." Once these necessary topics are determined, a sufficient amount of time should be devoted to them so that a very high per cent of those students going into the professions will be fairly competent in these areas.

With these recommendations taken into consideration, it is possible that our organized efforts in these curriculum revisions could produce a greater degree of mastery of algebra and higher mathematics by our students than we have at the present time. Thus we could prepare better mathematicians and scientists for the future.

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The Objective of Science Education

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So much has been said about the shortage of scientific manpower and the rapidity with which Russia is turning out technicians that we are apt to conclude that the primary objectives of science education are to fill an assembly line and to make sure that an adversary does not beat us in the race to see who can get somewhere "fustest with the mostest." This is not only misleading but also distracting, in that it tends to divert our attention from what appears to me to be much more important.

It seems quite true that the demands of both industry and the academic world for scientific talent far exceed the visible supply. One of the country's best known scientific figures has insisted that the situation in Russia is not a matter of "ifs" and "buts"; but she is turning out scientific workers at such a rate and of such a quality that in a few years she definitely *will* have more well trained scientific manpower than we. It is well to make these apparent facts widely appreciated, but nothing will be gained by arguing about them.

While we occasionally hear it said that the "shortage" is highly exaggerated and does not really exist, nevertheless, no one has ever doubted the shortage of really good scientists. In fact, such a shortage is manifestly impossible. The thing which the creative scientific thinker gives to the world is something which, like art, beauty, music, inspiration, and knowledge itself, we can never have in excess. These are the things which lift the whole human race, and the men who contribute them are not mere figures occupying a limited number of spots in an organization. They make their own places, outside all tables of statistics.

But what should be our aim in science education, if it is not to turn out trained artisans? It should be to arouse and nurture the desire to *know*. For knowledge is power, and the present measure of our control

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of nature is the result of what we have come to know about it. However, the end objective is not a mere comfortable world in which gadgets do the work of men. For knowledge is a desirable end in itself, and if this is lost sight of the upward surge of the human race will stop. This is the lesson we must teach.

When we urge the adoption of ideas in which we believe, we call it inspiration; when our opponent urges the adoption of ideas in which we do not believe, we call it propaganda. The world is full of such contests in many fields. We are in grave danger of losing the race in the political field because we are making a less effective effort at inspiration than our adversary is at propaganda. Unless we wake up from our lethargic enjoyment of the lush "consumer goods" of our luxurious standard of living and start to fire the young minds of the rising generation with the exciting ideals of our democracy, we may find ourselves overwhelmed by a generation raised in quite a different pattern of thinking.

Science is perhaps no respecter of political dogma, but certainly it can thrive effectively only in an atmosphere of freedom from all restraint. We must be sure that our conception of democracy provides this. We confidently believe that it does.

Science should be presented as an eternal quest for the unknown. This quest can be made purposeful and exciting, and the measure of the success of a science teacher is the extent to which he has accomplished this and inspired students with the desire to *know*. When this desire becomes an unconscious reaction all other problems become relatively insignificant. Then—and not until then—does vocational guidance become important, with its economic considerations and plans for further training.

Many vocations, and some professions, have a limited future, or are dependent upon conditions or developments beyond control. But the field of science is limitless in its effort to learn. And what we have thus far learned in the few hundreds of years of real scientific progress is only a small part of what will eventually be known about the world and the things that make it tick. Already we understand—at least partially—many phenomena which were once shrouded in savage supersitition; some day our present "superstitions" will be made rational. We are already making a good start at understanding the origin of the earth, the universe, the chemical elements, life itself. We may hope some day even to know the *meaning* of some of these things. What prospect can be more enticing than to have a small part in the unraveling of these mysteries? No one person will do it all, but every time an unusually bright mind is discovered and directed into this search the results are brought a little nearer and the hope of the whole world brought a little closer to the answer to the old question: "Why?"

1+1

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"Teacher, I can't add. How can I add better?"

"It's really very simple. Let's try it and see."

Since a primary focus of the reading class is to clarify concepts, questions in any area troubling the student are the first order of the period. The teacher makes no claim to knowing all the answers; she tries to work them out for the student, often as much for herself as for him. . . . This development was not preconceived, but emerged from the attempt to go from the simplest start to the resolution of the problem.

"You can add one and one, can't you?"

"Yes."

"Very well. Let's begin at the beginning.

One and one? Two.
One and two? Three.
One and three? Four."

This continued through nine, each number just one more than the one before. Then:

"Now let's take two.

Two and one? Three.
Two and two? Four.
Two and three? Five."

And again, through two and nine.

"Now let's take three.

Three and one? Four.
Three and two? Five.
Three and three? Six."

By this time, the class was beginning to get the sense of rhythm, each sum being just one more than the sum before, so that the progression came automatically, almost without thinking. This continued until nine, each total being entered in order on the board.

"Nine and one? Ten.
Nine and two? Eleven.
Nine and three? Twelve. . . . Nine and nine? Eighteen."

By the end, this was the table on the board:

The first number:	Plus 1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9	10
2	3	4	5	6	7	8	9	10	11
3	4	5	6	7	8	9	10	11	12
4	5	6	7	8	9	10	11	12	13
5	6	7	8	9	10	11	12	13	14
6	7	8	9	10	11	12	13	14	15
7	8	9	10	11	12	13	14	15	16
8	9	10	11	12	13	14	15	16	17
9	10	11	12	13	14	15	16	17	18

"You just have to get the feeling of how the numbers are to each other. See how each one is just one more than the one before? It is faster to add in your head, but with this table, you can check to see if you are right.

Just take the number on the side. Go along that line until you come to the column with the number at the top that you want to add to it. Where the row and column meet, there is your answer."

Semi-Micro Chemistry—Are You Converting?

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Since a shortage of space, both in school classrooms and in storage, is becoming an important issue, the value of semi-micro chemistry seems worthy of serious consideration. Research of the literature reveals however, that there is still some question as to the superiority of semi-micro methods over the macro methods. In an experiment with matched group covering the knowledge of concepts, ability to interpret data, ability to evaluate factors in experiment, ability to predict outcomes in experiments, skill in critical reading of statements of chemical functionality, and opinion concerning good laboratory techniques, Smith and others (11) found no significant differences. However, it was found that semi-micro chemistry was superior in the following categories: first, more experiments were performed; second, since less expensive equipment and fewer chemicals were required, the costs were less; third, health hazard related to fires, odors and cloth damage was less; fourth, better use was made of space; and last, building maintenance related to plumbing expenses, spilling damage, and corrosive fumes were less. They summarized that:

> "There is nothing which at present is done by students with large apparatus that cannot be done with the micro method, but there is much that can be done with small apparatus that is sheer waste when done on the large scale."

Besides emphasizing the saving of time and materials, Alyea (2) states:

> ". . . lecture demonstrations on a semi-micro scale are a boon to chemistry teachers who lack a lecture assistant or expensive chemicals."

Dobbins and Southern (7) and Arthur and others (1) agree that semi-micro chemistry is economical in time and money. The latter separate costs into two specific parts: the starting or introductory, and the current or maintenance.

Although Hoff and Brown (9) maintain that there is no substantial cost difference in equipping a laboratory with macro or semi-micro apparatus, their work mainly is concerned with answering questions which arise in the minds of teachers when discussing the merits of semi-micro methods.

Versatility of application to different fields of chemistry—general, qualitative, and organic— is proposed by Chelberg and Anderson (3). Dobbins and Kapp (6) agree that semi-micro techniques are very suitable for qualitative analysis. Dobbins and Southern (7) illustrate schemes which increase ease of manipulation, accuracy of results, economy of materials, and saving of time in qualitative analysis.

Gaddis and Breckenridge (8) claim that they present "data in this paper supporting the belief that the beginning course in quantitative analysis could be taught on a semi-micro basis." Waters (12) feels that accuracy in all respects is the greatest advantage of semi-micro chemistry over macro. Degering (5) agrees and further supports the argument for greater economy. He states that cost of working space and apparatus is cut in half and the cost of chemicals is cut from 10 to 50%. Wood (13) substantiates this by saying that cost of equipment is cut 30% and that the cost of chemicals can be cut as much as 75%.

Schiller (10) states:

> "The semi-micro method is to be highly recommended when laboratory space and finances are limited; when it is impossible to give individual equipment; when it is desired to reduce the danger element to a minimum, to have a laboratory free of fumes, to have students seated at their work with all necessary equipment within easy reach; and in general when it is desired to have experimentation carried out with utmost economy of space, time and materials."

Despite the values cited in the literature, chemistry teachers should view with caution any extraordinary claims of the superiority of semi-micro over macro methods. It is not the purpose of this paper to compare any learning outcomes, understandings or skill development of the semi-micro method with the conventional macro method but rather to point out that semi-micro methods seem workable in solving some teaching problems.

Semi-micro chemistry *can* have a place in the laboratory and the macro-type need not be discarded. The writer has recently been using semi-micro chemistry on an experimental basis for three years.

The changeover from macro to semi-micro chemistry in an established school is costly inasmuch as there is a two-fold problem: the purchasing of the new equipment, and the disposal of the old. The problem must be carefully considered and evaluated before any recommendation for a change should be made. Meanwhile there seem to be many advantages of semi-micro chemistry that require a small outlay of money and no great "upheaval." One or two sets of semi-micro chemistry equipment can be inexpensive and yet very useful in four general aspects of chemistry teaching:

1. The gifted can do better quality work.
2. Students can make up missed experiments with greater efficiency.
3. Science club members can experiment in a very effective manner.
4. Teachers of related fields of science can use the equipment in their special areas.

The gifted science student grows farther apart from his average classmate as he progresses through our educational system. By the time he reaches the senior high school, the gifted student poses many

problems in our "regular" classes because of this great difference. The teacher has special problems of motivation and stimulation besides wanting optimal development of each individual student. The "gifted," of course, are in a minority of any class, and yet they represent great potential that must not be overlooked. By using an individual semi-micro chemistry set, they can work at their own speed without causing extra work and preparation on the part of the teacher. This is an excellent way to take care of "individual differences." The instructor is a sort of consultant since the gifted can handle the routine work without much help. They take advantage of the opportunities for real quality investigations and experimentation. The gifted appreciate this type of mature treatment, and the regular class need not be affected.

The making up of missed experiments by individuals in a class poses another problem for the teacher. As our schools broaden their curriculums and as extra-curricular life becomes more important in the development of the student, classes are sometimes missed for many worthwhile reasons. As occasions arise for various meetings, officers of clubs or important committee members often find it necessary to be absent from class during experiments. Illness, too, adds to this problem. Teachers feel that a laboratory science is unique because of the opportunity for experimentation and regard these absences as lost opportunities for educational achievement. With the macro method, the instructor sets up the chemicals and special equipment necessary for a specific experiment. When the next experiment is to be performed, the chemicals from the previous work may have to be placed back in the supply room because of lack of space and the need for orderliness. With semi-micro sets, however, the student can always have all of the equipment at his disposal because of its completeness in character no matter how long after he has missed the experiment. This lightens the teacher's "clerical" burden and increases the students' effectiveness because it fits his "optional" time for best performance.

Another use of semi-micro chemistry involves the science club which has a number of amateur chemists who like to experiment. The field of experimentation is wide and unpredictable. If the teacher supervises this experimentation too closely, he may stifle initiative. The general supply room of chemicals and apparatus is apt to feel the effects of "unplanned" experimentation. Semi-micro chemistry is the perfect answer to these problems. Since the sets of semi-micro equipment are easily accessible they can be used at any time by interested students.

The portability of these sets makes it possible to use them in other

science classes. For example, most other sciences—from general science to physics—have some chapters or units dealing with chemicals and chemical changes. The sets can be used with teacher demonstrations within the class or by students when covering specialized subjects that may digress from the normal procedures.

Science teachers have unique problems. The laboratory makes their work more difficult and time consuming in many respects than that of their colleagues. Preparation, organization, and direction in the laboratory can be very trying at times; yet the value received is worth the effort. One aim of this paper is to show how some routine jobs can be performed more effectively and with less physical exhaustion to the teacher so that he may spend his time in more constructive ways.

In summary, even though we may use macro chemistry basically, semi-micro chemistry *has* a place in the laboratory. It is very effective when dealing with individuals and individual problems. The writer believes that if a school system is thinking about changing from macro to semi-micro techniques, experimentation on a small scale is the best way to determine the relative effectiveness of the methods.

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EVAPORATION CAUSES HIGH WATER LOSS

More than 21,000,000 acres of one-foot deep water is lost each year through evaporation from the water surfaces of streams, lakes, canals and reservoirs in the West. "Enough water is lost every year by evaporation in the 17 Western states to supply all the towns and cities of the country." the Department of the Interior reported. The U.S. Geological Survey is studying the savings that might be made by reducing evaporation losses in areas where water is in short supply.

A Non-Commutative Algebra

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It is often said that one does not properly appreciate something until he has to do without it. This certainly applies to algebra as much as anything else. Any discussion of the commutative, associative and distributive laws often falls rather flat because they appear so "obvious." We are so used to assuming the commutative law ($ab=ba$) in arithmetic and algebra that we miss its significance unless we work with a system where it does not apply.

It always does apply, of course, in arithmetic and in an algebra where the symbols represent numbers. The existence of non-commutative algebra has been known since 1843 when Hamilton discovered that quaternions did not obey the commutative law.[1] Besides quaternions one might mention the vector product of two vectors and the multiplication of matrices as examples of systems where the commutative law does not necessarily hold. Although these are important examples with many applications, they are rather difficult to explain on an elementary level.

The group of symmetries of a square[2] is an example of a non-commutative system that has the advantage of being easily understood and it can be developed in one class period.

The work can be prefaced by saying that we have been studying algebra where we assume the symbols represent numbers and the laws we use are those which are obeyed by ordinary numbers. There are, however, other kinds of algebra which might obey different sets of laws. Since we are boss of the symbols, we can give any meaning we wish to them. But once the meaning has been decided, it remains for us to determine what laws they obey.

Suppose we let our symbols represent, not numbers, but processes. For convenience, if one process is followed by another we call it *multiplication*. Thus if A means to add three and B means to multiply by six, AB means to add three and then multiply by six, but BA means to multiply by six and then add three. In general, this does not give the same result. We could let our symbols mean to turn a geometric figure in a certain way. We can then see whether these symbols obey the usual laws.

Each student can take a sheet of paper and cut or tear it into a square. The square is then marked so it is easy to tell when it is face

[1] E. T. Bell, *Men of Mathematics* (New York: Simon and Schuster, 1937), p. 360.
[2] Garrett Birkhoff and Saunders MacLane, *A Survey of Modern Algebra* (New York: The Macmillan Company, 1941), pp. 122–132.

up and right way around. Some students write their names at the top on one side or draw a picture of a man.

We find that the square can be placed in eight different positions (with sides parallel to the original) and we can give a symbol to the process that puts it into each position (Fig. 1).

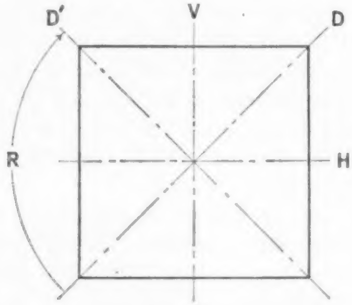

FIG. 1

- V means to turn the paper over by rotating it around the vertical center line (face down but right side up).
- H means to turn it over a horizontal center line (face down with top at the bottom).
- D means to turn it over the diagonal line from upper right to lower left (face down and top to right).
- D' means to turn it over the other diagonal (face down and top to left).
- R means to turn the paper to the right 90° (face up and top to right).
- R' means to turn it 180° (face up and top at bottom).
- R'' means to turn it 270° to right (face up and top at left).

These make seven operations. The eighth would be to leave it in the original position. We thus let I be our *neutral element* that means we do nothing but leave the square alone. Of course I could also mean to rotate any multiple of 360°.

Now we can try some multiplication like VV. This means we apply process V and then apply it again. First we turn the paper over so it is right side up and face down, then turn it over again the same way and it is back where it started. Thus $V^2=I$.

As we try other pairs of operations, we find, for instance, that applying V (leaves it right side up and face down) and then following it with D (leaves it face up and top to right) produces the same result as applying R in the first place. Thus we can write $VD=R$. Similarly we can find that D (leaves it face down and top to right) followed by V (leaves it face up and top to left) results in the same position as

R''. Thus, since $VD=R$ and $DV=R''$, it is evident that the commutative law does *not* hold.

The multiplication table (Fig. 2) can be well started in one class period and then finished at home. It is understood that the process on the left is performed first followed by the one on top. When the table is finished a number of questions can be answered by examining it.

1. Is the system *closed?* In other words, is the product of two operations always another operation of the set?
2. Is the *associative law* obeyed: $a(bc)=(ab)c$?
3. Is there a *neutral element*[3] e such that $ea=ae=a$ no matter which operation a might represent?
4. Does each element have an *inverse?*[4] That is, can we always find values of x which satisfy the equation $ax=e$ no matter what operation a might represent?
5. Does the *commutative law* hold? That is, does $ab=ba$?

If some student wishes to pursue the matter further, there are several possibilities.

First, it could be pointed out that the system forms a *group*[5] because (a) it is closed, (b) it is associative, (c) it contains a neutral element, and (d) each element has an inverse.

	I	V	H	D	D'	R	R'	R''
I	I	V	H	D	D'	R	R'	R''
V	V	I	R'	R	R''	D	H	D'
H	H	R'	I	R''	R	D'	V	D
D	D	R''	R	I	R'	H	D'	V
D'	D'	R	R''	R'	I	V	D	H
R	R	D'	D	V	H	R'	R''	I
R'	R'	H	V	D'	D	R''	I	R
R''	R''	D	D'	H	V	I	R	R'

FIG. 2

[3] Often called the identity element. Zero is the familiar identity element for addition since $a+0=0+a=a$. One is the familiar identity element for multiplication since $a\times 1=1\times a=a$.

[4] Two elements that produce the neutral or identity element are said to be inverses. Thus $+2$ and -2 are inverses under addition because $+2+(-2)=0$. And 2 and $\frac{1}{2}$ are inverses under ordinary multiplication because $2\times\frac{1}{2}=1$. In the system described here R and R'' are inverses because $RR''=I$.

[5] Richard V. Andree, *Selections from Modern Abstract Algebra* (New York: Henry Holt and Company, 1958), p. 79; *Insights into Modern Mathematics* (Twenty-third yearbook, Washington, D. C.: The National Council of Teachers of Mathematics, 1957), pp. 106, 133; M. Richardson, *Fundamentals of Mathemetics* (revised edition; New York: The Macmillan Company, 1958), p. 467.

Second, the problem of solving for x in equations like $Rx=H$ and $xR=H$ could be investigated. From examining the multiplication table we find that the solutions are $x=D'$ and $x=D$ respectively. Since the equations have different solutions, it is *not* satisfactory to write the solutions as H/R or $H \div R$. We can, however, solve the first equation systematically by multiplying both sides of the equation on the *left* by the inverse of R (written R^{-1}).

$Rx=H$	[Original problem]
$R^{-1}Rx=R^{-1}H$	[Multiplying both sides of the equation on the *left* by the inverse of R]
$Ix=R^{-1}H$	[From definition of inverse]
$x=R^{-1}H$	[From definition of neutral element]
$R^{-1}=R''$	[Observed from table]
$x=R''H$	[Substituting the inverse of R]
$x=D'$	[Reading the product of R'' and H from the table]

In the second equation we should start by multiplying by R^{-1} on the *right*. Thus we see that although H/R is ambiguous, $R^{-1}H$ and HR^{-1} are not and can be used.

Third, the existence of ***subgroups*** could be pointed out. That is, groups can be formed from less than the full eight transformations. For example, I and H form a subgroup, and I and V form a subgroup.

Fourth, multiplication tables for other groups of geometric transformations could be constructed. A rectangle, equilateral triangle, or regular hexagon could be tried. A very ambitious student might try the group for rotations of a cube. A cube has 24 symmetries and the multiplication table has $24 \times 24 = 576$ entries in it.

BEE-VENOM EXTRACT HELPS THOSE WHO GET STUNG

A bee-venom extract that is made from whole bees has been found to be a helpful desensitizing agent for people who experience severe reactions from bee stings.

The whole bee extract is made from hundreds of bees that are chloroformed in closed containers. The bodies are washed in a colander with cold water, spread to dry, and then ground into a thick paste. The paste is then squeezed through a fine double-muslin bag and filtered. The clean fluid that is recovered constitutes the "whole bee" extract.

The whole bees were used instead of just the material from the sting apparatus because earlier investigations revealed that persons sensitive to bee stings reacted similarly to both the whole bee and stinger extracts. This indicated that that was a common antigen, or desensitizing agent, and since handling of the whole body was easier, use of the stinger alone was abandoned.

Desensitization is accomplished by injecting the extract between the layers of skin.

Utilizing the Exceptional Student in Space Age Science

Malcolm H. Filson
Central Michigan College, Mt. Pleasant, Michigan

The advent of the space age science has made necessary the adoption of a new system of science instruction at Central Michigan College, Mt. Pleasant, Michigan, which is believed will be duplicated shortly by many institutions of learning throughout the country, for both college, secondary and elementary schools.

The program briefly is that of using exceptional students in the classroom to assist in both physics and chemistry classes and laboratory instruction.

Shrunken budgets, increased size of classes, shortages of both physics and chemistry teachers, lack of classroom and laboratory facilities, and criticism that many students today are not properly trained, (and are far behind those being trained in certain foreign countries) have made it mandatory to devise a revised program of instruction for undergraduate college teaching, and one which might easily be applied to both elementary and secondary classrooms.

A recent report of a two-year study by Rockefeller Brothers Fund, Inc. called for immediate changes in teaching methods, so that more talented students can be pushed along and not held back by average or slow groups.

The crisis in science education, the report revealed "is not an invention of the press or scientists. It is a real crisis." The widely held view that all problems in science education will be solved with a few more teachers, buildings and money is a mirage. It will lead to disaster. We must immediately use what we already have at hand.

The belief is that unless a new system can be formulated, present day students will be handicapped as improper and partially trained, with little or no laboratory experiences in many instances, and the result: they will be unable to meet and compete with their colleagues in this age of space science.

The program at Central Michigan College has a two-fold purpose; that of utilizing the talent of the exceptional student to help other students, and at the same time stimulate this young mind to more productive activities, instead of allowing it to remain dormant and immobile until the average or slower students have completed, caught up with the work or a new course started.

In some instances these exceptional students are hired at the prevailing student wage as undergraduate assistants, and duties consist of assisting with large class instruction quizzes, laboratory assisting,

lecture demonstrations, and other laboratory routine, along with the usual paper correcting activities and teacher assistance.

Recent statistics released by the American Institute of Physics as reported by Dr. Elmer Hutchison, revealed the supply of physics teachers in the United States colleges and universities is gloomy with with no promise that it will get better in the immediate future. A similar situation exists in both chemistry and physical science fields.

In 1958 only 39 of 490 colleges and universities with four year undergraduate physics programs, report that physics teacher needs are being met. There is an immediate need, the report points out, for 688 Ph.D. physicists for colleges alone, and more than half the schools surveyed, reveal teachers are carrying "overloads," with no time for research or scholarly activities. The report makes no mention of secondary education needs. The chemistry situation is equivalent, and that of trained physical science teachers for elementary and secondary schools is tragic in this science age.

For the past two years, the use of these exceptional students has been a part of the training program at Central Michigan College, where possible, and it has been effective. Fellow students respect their more talented colleagues, do not hesitate to ask questions or seek their assistance, although they frequently hesitate to request help from a staff member or professor.

The exceptional student also excels in the presentation of original ideas for lecture and laboratory demonstrations. His interpretations are new, stimulating and challenging to both fellow students and instructors.

A final analysis also reveals that this type of training provides the student with a greater knowledge of the literature, use of the library and its facilities. At the same time many of the students voluntarily visit research and industrial concerns to gain first hand information and experiences. This too is shared with the entire class.

Both pre-professional and students preparing to be teachers are used in the program.

The program will train, save, stimulate and elevate science training in our present day educational systems. It can easily be applied and adopted to any laboratory science class.

Journals Needed

The library at the University of Wichita needs volumes 2, 3, and 4 of School Science and Mathematics to complete its file. If any reader has all or a portion of these and would be willing to sell, please communicate with Prof. Cecil B. Read, University of Wichita, Wichita 14, Kansas.

Priorities in Reappraisal for Science Education in Louisiana Schools*

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Foremost in the minds of administrators of the Negro school in the south is the problem of overcoming the cultural deprivation attending the majority of its pupils and adequately preparing them to compete in a technical society. The enormity of this task makes adequate provisions for learning in the sciences assume high value in these times.

The purpose of this study was to identify critical areas for reappraisal in the science programs in the Negro Secondary Schools in Louisiana. The study also attempted to weight the immediacy of the several facets of needed change and to establish sequential priorities for study and improvement.

The study proceeded from the basic assumption that adequate provisions for learning in science are to a large extent dependent upon the following variables:

1. Experienced science teachers who have enjoyed long tenure at a given station.
2. Teachers who are constantly improving themselves in service.
3. Teachers who are privileged to work in a highly professional atmosphere of scholarship and dedication to academic pursuits.
4. A curriculum which provides for learning experiences in those areas of science which adjustment in a technical society make necessary.
5. Physical facilities and resources which will implement the curriculum objectives.
6. Adequate guidance services which make the curriculum of the school meaningful.

Study of conditions in Louisiana schools proceeded on a tripartite of questionnaire surveys of a random sample of institutions, visits to a selected sample of institutions and interviews with principals and head science teachers. There were 146 high schools (grades 9–12 or grades 9–11) located in 64 parishes in the state and in three city school districts when the study was begun. One secondary school was selected for study from every third parish and from the three city districts (a total of 25 schools). The questionnaire was used for the entire sample. After the results were tabulated, visits to ten additional institutions (representing every sixth parish) were made. Interviews with principals and head science teachers were completed on these visits. The intent here was to corroborate by first hand observa-

* A Report of the State Science Study of the Louisiana Education Association.

† Dr. Rand is now serving as Executive Dean at Jarvis Christian College, Hawkins, Texas.

tion and study the conclusions drawn from the questionnaires. To ascertain the reliability of sampling the standard errors of the means

$$\left(\sigma m = \frac{\sigma}{\sqrt{N}}\right)$$

and per cents and proportions

$$\left(\sigma\% = 100\ \frac{\sqrt{PQ}}{N}\right)$$

were used with a correction for negative bias due to small sample[1] where formula for σm has been modified to

$$\sigma m = \frac{\sigma}{\sqrt{N-1}}\ .$$

Interpolation of levels of significance were completed by comparison of σm with tables of the normal probability curves.[2] The study revealed concrete and heartening evidence of concerted efforts to provide adequate learning opportunities for the Negro child in Louisiana; however, it also revealed ample room for study and improvement. In the years of self searching that must surely follow in the continued struggle to prepare the Negro child for life in the technical society of these times, these follow as sequential priorities in reappraisal.

Reorientation of the Curriculum to Provide More Learning Opportunities in the Physical Sciences

Perhaps the most startling revelation of the study was the austerity of learning opportunities in physics, physical science and chemistry and in the supply of teachers to teach these subjects. In the sample of 61 teachers employed in the 25 schools sampled 4.9% were trained to teach physics and 26.3% chemistry as compared to the 45.9% and 22.9% trained to teach biology and general science respectively (table II gives further analysis).[3] This corresponds with and perhaps offers the raison d' etre for the lack of students taking these courses, 13.6% for chemistry and .5% for physics (table IV).

In a time when the emphasis in scientific endeavors and the general world of work is directed toward physical phenomena, it seems important that these children have the opportunity to prepare themselves for competitive living found in such a society.

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[1] Garrett, Henry, *Statistics in Psychology and Education*. New York: Longman-Green, 1945. Pp. 189.

[2] *Loc. cit.*, p. 115.

[3] To facilitate continuity in summarizing the findings, all tables have been placed in sequence at the end of the study.

Study Ways and Means to Create a Greater Supply of Teachers in the Physical Sciences

As has been intimated in the foregoing discussion, the critical point in the alleviation of this depravity is to be found in teacher supply. This thesis was adequately borne out to the investigators in their interviews with local authorities and while teacher supply in these areas is a national problem, certain problems of a provincial and cultural nature further complicate the efforts of these authorities to staff their schools. Data on graduating science teachers received from deans of the five colleges and universities in Louisiana which train teachers for these schools failed to yield heartening results here. School people in Louisiana must concert their efforts to solve this problem. Strong physics and chemistry minors developed through further study, subject matter workshops, additional incentives—somewhere lies the solution. And above all, able and concerted recruitment and retention on the part of teacher training institutions is the sine-qua-non if the depravity cycle is to be destroyed.

Study How Best to Encourage and Help More Students to Take More Sciences to Learn More About Scientific Careers, to Set Career Goals in Science and to Become Established in the Next Step Activities Necessary to Reach These Goals

This is surely guidance and the findings of the study echo the observations of Conant on vocations and sense of purpose in high school students. Conant[4] notes that:

> "The great majority of high school students should be directing their studies toward some definite end ———— These are the committed students and ideally they should constitute the entire student body. If this were the case many of the justifiable criticisms of the soft high school programs would disappear, for it is the program of the uncommitted students which is usually without rhyme or reason, a jumble which produces no challenge to any aptitude or talent."

It is significant that 91% of the sample schools in the study indicated that more guidance on occupational opportunities and requirements in science is needed (table VIII). It is also significant that Louisiana, like most other states, has just begun to realize the full importance of adequate coordinated guidance services in its schools. A case in point is the paucity of follow-up gleaned from the schools in this study (table IX). Margaret Mead[5] reports alarmingly on the negative imagery held by some American children for scientific pursuits and the works of Ginsberg[6] in weighing the Negro po-

[4] Conant, James, "The Gifted Child and the High School Curriculum." An Address delivered to the 1958 Convention of the National Association of Secondary School Principals.

[5] Mead, Margaret, "How American Youth Sees the Scientist: the Dangerous Godless Brain." *Look Magazine*, XXII (January 21, 1958), 20.

[6] Ginsberg, Eli, *The Negro Potential*. New York: Columbia University Press, 1956.

tential points up with great clarity the task of Louisiana educators in overcoming mental blocks, cultural depravity and isolations and leading the Negro adolescent into the realms of endeavors which he has had only secondary and tertiary experiences with, and where employment opportunities lie in areas far removed from the comforting confines of his parish. It is heartening to note the position and efforts on the part of the Louisiana State Department of Education in this field as well as positions and efforts at the national level. It remains for local school boards, superintendents and principals to implement the thinking of the times.

Expand the Science Facilities in the Schools to Include Laboratories and Equipment for the Special Disciplines

Louisiana schools are the marvel of the south. Wonderfully endowed with revenues from industries and natural resources and with a commendable strength in the will to provide educational opportunities for their children, the people of Louisiana spend at a rate which ranks them fourth among all states in the nation.[7] Sparkling new schools with copious facilities are in evidence all over the land.

There is evidence however that attention must be given in future planning and the expansion, which will surely come, to providing facilities and equipment for the special disciplines. General science and combination laboratories constituted 80% of the facilities found in the schools studied (tables V, VI, and VII). Interest and competence in an academic discipline flourishes in an academic atmosphere under the tutelage of academicians equipped with the instruments of their profession. To broaden young perceptual fields and to stir young interests and aspirations demand that these plastic organisms live and work and study in the welter of specimen and models and countless samples of matter, flora and fauna of this planet which are so necessary to completely laboratize and thereby realize the optimum in learning experiences.

Study to Ascertain How Best to Lend More Purpose to the Activities of the Science Activities of the School

It is probable that nothing can compensate in the science program from the concertion of efforts of well trained purposeful teachers, teachers who are genuinely interested in their young charges, who understand the behaviors of adolescents and the bases for these behaviors, ever sensitive to the needs of their group and eager to implement the rapid strides being made by their people in the technical and scientific societies which prevail in these times. And these

[7] "*The States and Education*," National Education Association Research Bulletin, XXXVI, No. 1, Washington, National Education Association, 1958, P. 83.

professionals must be priviledged to work in atmospheres which will encourage the development of their maximum potentials.

Science teachers in Louisiana have adequate experience averaging 7.7 years per teacher with a standard deviation of 3.8 in a sample which was significant at the .01 level. They enjoy tenure in their positions 5.9 years, 4.7 standard deviation at the .01 level (table I).

These teachers are also well trained, 67.0% holding the Bachelor of Science, 13.1% the Bachelor of Arts and 19.9% the Master of Arts or Science. One teacher is a candidate for the Ph.D. degree and 24.5% were engaged in advanced degree study (table II).

There was evidence however, that the laboratories in the future will lose some of its more able researchers to administrators desks as all with the exception of two were engaged in study to prepare them for tasks in the schools other than teaching science. This finding corroborated the hypothesis developed by the investigators during the visitations that ways and means must be found to better enable science teachers to realize complete fulfillment in their work. Departmentalizing science activities will surely make giant strides in this direction. "Everybody's business is nobody's business" holds true in science teaching and professionals must have business—a mission and a strong sense of it if he is to realize fulfillment and if the activities of the department are to flourish in a goal centered and purposeful manner.

And finally the schools and science in Louisiana must somehow, somewhere achieve democracy and excellence in human relations as it ministers its programs. In the past and at this writing far too many developmental opportunities for the children have been destroyed on the sacrificial block of tension in human interaction and dualities in purposes. A professional is one who is competent in *all* phases of his work. Humans must group for survival and teaching and learning is the epitome of the group process. Rapid strides are being made in the researching of this area. It remains for all the teachers in all the schools to avail themselves and their young charges of the benefits of the emergent truths, and through a sustained concertion of efforts bring to bear the full complement of all human and physical resources necessary to enable these children to share the rewards of the greater world.

TABLE I

TEACHING RESPONSIBILITIES AND TENURE OF SCIENCE TEACHERS IN LOUISIANA SCHOOLS (ALL SCHOOLS)

$N=61$

	Mean	σ	σm	Level of Significance
Years of teaching experience in Science	7.7	3.83	.69	.01
Years in present position	5.98	4.71	.88	.01
Number of Science classes taught	3.7	1.57	.53	.01

TABLE II

PRE-SERVICE PREPARATION OF SCIENCE TEACHERS IN LOUISIANA SCHOOLS

$N=61$

Areas of Certification	Number	Per Cent
Biology	28	45.9
Chemistry	16	26.3
Physics	3	4.9
General Science	14	22.9

TABLE III

DEGREE LEVELS AND IMPROVEMENT IN SERVICE OF FACULTY

$N=61$

Status and Study	Number	Per Cent
Bachelor of Science	41	67.2
Bachelor of Arts	8	13.1
Master of Science	6	9.9
Master of Arts	6	9.9
Engaged in Advanced Study	15	24.5

TABLE IV

PER CENT OF STUDENTS WHO TOOK SCIENCE COURSES BY GRADES

Courses	Median Percentiles by Grade Levels					
	9	10	11	12	σP*	Level of Significance
General Science	89.2	0.0	0.0	0.0	.032	.05
Advanced General Sc.	0.0	.8	.8	.4		
Biology	0.0	81.2	6.6	.4	.030	.05
Chemistry	0.0	0.0	13.6	18.3		
Physics	0.0	0.0	0.0	.5		
Totals	89.2	82.0	21.0	19.6		

* Standard error of per cent is based on assumption that 100% of students should take these sciences in these grades.

TABLE V

TYPES OF LABORATORIES

$N=25$

Types	Number	Per Cent
Combination	15	60.0
General Science	5	20.0
Biology	3	12.0
Chemistry	2	8.0
Physics	0	0.0

TABLE VI

BASIC INSTALLATIONS AND EQUIPMENT FOR SCIENCE CLASSROOMS AND LABORATORIES

$N=25$

Equipment and Installations	Number of Laboratories				
	General Science	Chemistry	Physics	Biology	Combination
Demonstration desks	9	7	2	8	10
Student Laboratory stations	67	48	0	82	131
Gas outlets for laboratory stations	57	40	0	58	57
Gas outlets for demonstration desks	13	11	4	12	15
Water outlets for laboratory stations	32	30	0	30	120
Water outlets for demonstration desks	10	8	3	9	10
Electrical outlets for student laboratory stations	42	14	0	48	57
Electrical outlets for demonstration desks	9	7	1	3	2

TABLE VII

AN EVALUATION BY TEACHERS AND PRINCIPALS OF THE BASIC EQUIPMENT IN THEIR LABORATORIES BY USE OF THE BASIC EQUIPMENT CHECK LIST

	Per Cent Ratings by Scale for Evaluation					
	N	Low	Less than Adequate	Adequate	More than Adequate	Superior
General Science*	25	.4	48.0	32.0	12.0	8.0
Biology	25	.4	48.0	24.0	5.0	23.3
Chemistry	19	11.0	57.9	10.5	10.5	10.5
Physics	11	36.3	72.7	0.0	0.0	0.0

* General Science equipment to be selected from combination of all areas.

TABLE VIII

AN EVALUATION BY TEACHERS AND PRINCIPALS OF WAYS AND MEANS OF RECRUITING MORE ABLE STUDENTS INTO SCIENCE TRAINING

$N=23$

Ways and Means	Per Cent Rating by Scale for Evaluation		
	Not Needed in Our Situation	Needed to Some Degree in Our Situation	Acutely Needed in Our Situation
More funds to buy equipment and supplies	9.0	43.0	48.0
More Science taught in the elementary grades	18.0	52.0	30.0
Sounder Mathematics backgrounds for students	18.0	39.0	53.0
Additional Science teachers	18.0	34.0	48.0
More guidance on occupational opportunities and requirements in science	9.0	63.0	28.0

TABLE IX

PLACEMENT IN SCIENTIFIC PURSUITS OF HIGH SCHOOL GRADUATES

$N=10$

Placement Situation	Per Cent Placed by Area			
	Biology	Chemistry	Physics	Other Sciences
Undergraduate College	3.4	2.1	0.0	2.7
Trade, Technical School or Junior College	.7	.5	0.0	.2
Immediate Employment in Technical Work	.1	.2	0.0	0.0

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On the Equation $ax - by = c$

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For the equation $ax-by=c$

$$y=\frac{c-ka}{d}, \qquad x=\frac{c(d+b)-bka}{ad} \tag{1}$$

with k and d positive or negative, are the solutions.

Assuming a, b, c integers, a prime to b, and putting

$$a-b=d, \tag{2}$$

we want to find the minimum positive integer value of y.

c can be represented as

$$c=aq+r=a(q-s)+as+r, \tag{3}$$

where q is the integer quotient of the division of c by a, r the rest of the division and s any number positive or negative.

From (3):

$$c-a(q-s)=as+r.$$

Substituting in (1) $q-s$ for k, we have

$$y=\frac{c-a(q-s)}{d}=\frac{as+r}{d}\,. \tag{4}$$

Should y have the minimum positive integer value, s has to be selected with the right sign so, that $as+r$ be the minimum divisible by d; it will be an integer. Then the corresponding value of x is also an integer, for:

$$y=\frac{c-a(q-s)}{d}=\frac{c-(b+d)(q-s)}{d}=\frac{c-b(q-s)}{d}-(q-s).$$

y and $q-s$ being integers,

$$\frac{c-b(q-s)}{d}$$

is an integer.

Now

$$x=\frac{c+b\,\dfrac{c-a(q-s)}{d}}{a}=\frac{c(d+b)-ab(q-s)}{ad}$$

$$=\frac{ca-ab(q-s)}{ad}=\frac{c-b(q-s)}{d}=\text{integer.}$$

Examples.

a. $a>b$.

$$19x-11y=12357; \qquad 12357=650.19+7$$
$$d=8; \qquad q=19;\ r=7$$

According to (4):

$$y=\frac{19s+7}{8}=2s+\frac{3s+7}{8}\ .$$

Now it is easy to see that for $s=3$, $(3s+7)/8$ has the minimum integer value. Hence

$$y=2.3+2=8; \qquad x=655.$$

If the reduced fraction $(3s+7)/8$ does not permit an easy determining of s, repeat the procedure, as shown in the following example.

$$125x-87y=861; \qquad 861=125.6+111$$
$$d=38 \qquad q=6;\ r=111$$

$$y=\frac{125s+111}{38}=3s+2+\frac{11s+35}{38} \tag{5}$$

It is rather difficult to find the s making $(11s+35)/38$ an integer; it is seen though that s can be only an odd number. Put

$$\frac{11s+35}{38}=u\ \therefore\ 38u-11s=35; \qquad 35=38.0+35$$
$$d=27 \qquad q=0;\ r=35$$

$$s=\frac{38s_1+35}{27}=s_1+1+\frac{11s_1+8}{27}\ . \tag{6}$$

Suppose we still don't see the value of s_1. Put

$$\frac{11s_1+8}{27}=w\ \therefore\ 27w-11s_1=8; \qquad 8=27.0+8$$
$$d=16 \qquad q=0;\ r=8$$

$$s_1=\frac{27s_2+8}{16}=s_2+\frac{11s_2+8}{16}\ .$$

It is easy to see that for $s_2=8$, $(11s_2+8)/16=6$.

$$\therefore\ s_1=8+6=14.$$

From (6):

$$s=\frac{38.14+35}{27}=21,$$

and from (5):

$$y=\frac{125.21+111}{38}=72; \qquad x=57.$$

b. $a<b$, i.e. $a-b=-d$, then $-as+r$ divided by $-d$ must be a positive integer.

$$11x-20y=12361; \qquad 12361=11.1123+8$$

$$d=-9 \qquad q=1123;\ r=8$$

$$y=\frac{11s+8}{-9}=-s+\frac{2s+8}{-9}$$

For $s=-13$, $(2s+8)/-9=2$

$$y=13+2=15; \qquad x=1151.$$

c. $a>b$, c negative

$$25x-11y=-117; \qquad -117=25\cdot(-4)-17$$

$$d=14 \qquad q=-4;\ r=-17$$

$$y=\frac{25s-17}{14}=s+\frac{11s-17}{14}\cdot$$

Put

$$\frac{11s-17}{14}=u\ \therefore\ 14u-11s=-17; \qquad -17=-14.1-3$$

$$d=3 \qquad q=-1;\ r=-3$$

$$s=\frac{14s_1-3}{3}=4s_1-1+\frac{2s_1}{3}\cdot$$

For $s_1=3$, $2s_1/3=2$ and $s=13$

$$y=\frac{25.13-17}{14}=22; \qquad x=5.$$

d. $a<b$, c negative

$$17x-29y=-235; \qquad -235=17\cdot(-13)-14$$
$$d=-12 \qquad q=-13;\ r=-14$$

$$y=\frac{17s-14}{-12}\cdot$$

For $s=-2$, $y=4$; $x=-7$.

e. If d and r are such that $d=kf$ and $r=nf$, then

$$y=\frac{as+n}{k}\cdot$$

$$157x-118y=24567; \qquad 24567=157.156+75$$
$$d=39=13.3 \qquad q=156;\ r=75=25.3$$
$$y=\frac{157s+25}{13}=12s+1+\frac{s+12}{13}$$

For $s=1$, $y=12+1+1=14$; $x=167$.

An interesting case represents the equation $ax-by=1$ (7) with $a-b=2$.

Decompose a into two summands p and q whose difference is 1, $p-q=1$. Then p is y and q is x.

Proof. We have: $a=p+q$, $b=p+q-2$, $p-q=1$. These values in (7), gives

$$(p+q)q-(p+q-2)p=pq+q^2-p^2-pq+2p=(q+p)(q-p)+2p$$
$$=-q-p+2p=p-q=1.$$

$$37x-35y=1; \qquad x=18; \qquad y=19.$$

If $a-b=-2$, then p is x and q is y:

$$5x-7y=1; \qquad x=3; \qquad y=2.$$

If $ax-by=-1$, with $a-b=2$, then decompose b into two summands as before, and p is x and q is y:

$$9x-7y=-1; \qquad x=3; \qquad y=4.$$

If $a-b=-2$, then p is x and q is y:

$$7x-9y=-1; \qquad x=5; \qquad y=4.$$

Problem Department

Conducted by Margaret F. Willerding

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

2623. *Proposed by Lowell T. Van Tassel, San Diego, Calif.*

A mathematical marksman takes a pot-shot at a one inch cube. Assume the bullet trajectory to be a straight line, and to pierce the target. If the cube is randomly spun before it is tossed into the air, what is the probability that

(a) Any two adjacent faces will be pierced?

(b) Any two parallel faces will be pierced?

(c) Does $PR(a)+PR(b)=1$; i.e., are (a) and (b) exhaustive, assuming the cubical target to be hit?

Solution by Leon Bankoff, Los Angeles, Calif.

After piercing a face of the cube, the bullet may pierce any one of the five remaining faces, four of which are adjacent to, and one parallel to the first face. Hence

$$PR(a)=4/5$$

$$PR(b)=1/5$$

$$PR(a)+PR(b)=1$$

2624. *Proposed by C. W. Trigg, Los Angeles City College.*

Each of the letters in $(FB)(CA)=(BA)(DC)=EEE$ uniquely represents a digit. Decode the problem.

Solution by the proposer

EEE must be a multiple of $111(=3.37)$ and the four two-digit factors are distinct, so 37 must be one of one pair, and 74 one of the other pair. Hence, E is even and $\leqq 8$.

The other factor is a two-digit multiple of 3, the smallest of which is 12. Hence, one factor pair is (74)(12) and the other is (37)(24).

It follows that $E=8$, $A=4$, and $B=2$ or 7, $C=7$ or 2, $D=3$ or 1, $F=1$ or 3.

Solutions were also offered by Leon Bankoff, Los Angeles, Calif.; Benjamin Greenberg, Fort Hamilton High School; Felix John, Philadelphia, Pa.; H. R.

Leifer, Pittsburgh, Pa.; Warren Rufus Smith, Lake Leelanau, Mich.; and Alan Wayne, Baldwin, N.Y.

2625. *Proposed by John Satterly, Toronto, Canada.*

If I is the incenter of triangle ABC with sides a, b, and c, prove

$$a\cdot IA^2+b\cdot IB^2+c\cdot IC^2=abc.$$

Solution by Leon Bankoff, Los Angeles, Calif.

Since

$$a=2R\sin A=4R\sin\frac{A}{2}\cos\frac{A}{2}\quad\text{and}\quad IA^2=r^2\csc^2\frac{A}{2},\ \text{etc.},$$

we have

$$a\cdot IA^2+b\cdot IB^2+c\cdot IC^2=4Rr^2\left(\cot\frac{A}{2}+\cot\frac{B}{2}+\cot\frac{C}{2}\right)$$
$$=4Rs$$
$$=abc$$

Solutions were also offered by Arthur Adams, Ithaca, N. Y.; Jennie Bodine, High Point, N. C.; A. R. Haynes, Tacoma, Wash.; Brother Norbert, Chicago, Ill.; Cosmel R. Davis, Pocatello, Idaho; Aaron Sheridan, Fort William, Canada; Mrs. Walter R. Warne, St. Petersburg, Fla.; Dale Woods, Pocatello, Idaho; and the proposer.

2626. *Proposed by A. R. Haynes, Tacoma, Wash.*

A circle of given radius passing through the focus, S, of a given conic intersects it in A, B, C, and D. Show by means of polar equations $SA\cdot SB\cdot SC\cdot SD$ is a constant.

Solution by Leon Bankoff, Los Angeles, Calif.

Let the equation of the conic be $l=r(1+e\cos\theta)$, where l is the semi-latus rectum, r the focal radius, e the eccentricity and θ the vectorial angle. If a is the radius of the circle passing through the focus of the conic, the polar equation of the circle is $r=2a\cos(\theta-\alpha)$, where α is the angle between vectors to the conic and the circle.

Since $\alpha=0$ for the four radii to the intersections, we have

$$(r-2a\cos\theta)^2=0$$

From the equation of the conic,

$$\cos\theta=(l-r)/er$$

So

$$[er^2-2a(l-r)]^2=0.$$

The product of the roots of the resulting quartic is $4a^2l^2/e^2$, a constant. Hence $SA\cdot SB\cdot SC\cdot SD$ is constant.

A solution was also presented by the proposer.

2627. *No solution has been offered.*

2628. *No correct solution has been offered.*

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2624. *Wallace G. May, Fort Townsend, Wash.*

2624. *Jeralyn Delisi, Pittsburgh, Pa.*

PROBLEMS FOR SOLUTION

2647. *Proposed by John Nayler, Calgary, Alberta.*

One disc of 20 in. diameter and one of 10 in. diameter are cut from a 30-in. diameter disc of plywood. What is the largest disc that can then be cut from the remainder of the plywood?

2648. *Proposed by Cecil B. Read, Wichita, Kansas.*

For real values of x, determine whether x^3+1 is larger than x^2+x.

2649. *Proposed by Felix John, Philadelphia, Pa.*

If the sides of a triangle are in arithmetic progression, the corresponding altitudes are in harmonic progression.

2650. *Proposed by C. W. Trigg, Los Angeles, Calif.*

In how many essentially different ways may 27 congruent cubes, of which 9 are red, 9 are white, and 9 are blue, be assembled into a $3\times3\times3$ cube so that no row, column or pile contains two cubes of the same color?

2651. *Proposed by Brother Norbert, Chicago, Ill.*

Prove that the sum of the radii of the three escribed circles of a triangle is equal to the radius of the inscribed circle plus four times the radius of the circumscribed circle.

2652. *Proposed by C. N. Mills, Sioux Falls College, S. D.*

Given $f(x)=ax^3+bx^2+cx+d$ and $g(x)=dx^3+cx^2+bx+a$. In order that $f(x)$ and $g(x)$ have a common linear factor, show that the necessary conditions are $a-b+c-d=0$ and $a+b+c+d=0$.

VITAMIN K HAS VITAL ROLE IN PHOTOSYNTHESIS

A further step in understanding the mystery of photosynthesis, the process by which green plants use light to make their food, has been taken.

Vitamin K, important in human diets since it is necessary to coagulate blood, apparently also plays a vital role in plant life. It seems to be a chemical catalyst present in chloroplasts, the green particles found in some plant cells. A catalyst helps a reaction take place without actually participating in it.

Experiments have been reported in which chloroplasts have been isolated from spinach leaves. Moisture and fat-soluble chemicals were removed and in solution the chloroplasts could no longer perform their complex photosynthetic reactions.

However, when man-made forms of vitamin K were added to the solution one important reaction was restored. The chloroplasts were able to convert water and ferric iron to hydrogen, ferrous iron and free oxygen.

It is believed vitamin K may act as a "neutral corner" for hydrogen atoms that have been separated from water. The hydrogen later combines with carbon dioxide to make carbohydrates, another step in photosynthesis. Without the vitamin, the hydrogen would ultimately rejoin the oxygen and form water again.

Books and Teaching Aids Received

A MODERN APPROACH TO INTERMEDIATE ALGEBRA, by Henry A. Patin, *Chicago City Junior College*. Cloth. Pages viii+244. 14×21 cm. 1958. G. P. Putnam's Sons, 210 Madison Ave., New York, New York. Price $3.75.

EDUCATORS GUIDE TO FREE SLIDEFILMS, Compiled and Edited by Mary Foley Horkheimer and John W. Diffor. Paper. Pages viii+206. 21×27.5 cm. 1958. Educators Progress Service, Randolph, Wisconsin. Price $6.00.

ELEMENTARY NUMBER THEORY, by Edmund Landau, Translated by Jacob E. Goodman, *Columbia University*. Cloth. 256 pages. 15×23 cm. 1958. Chelsea Publishing Co., 50 E. Fordham Road, New York 68, N. Y. Price $4.95.

FUNCTIONS OF REAL AND COMPLEX VARIABLES, by William Fogg Osgood. Cloth. Pages xii+407, and xiii+262. 13.5×20 cm. 1958. Chelsea Publishing Co., 50 E. Fordham Road, New York 68, N. Y. Price $4.95.

THE HIGH SCHOOL IN A NEW ERA, edited by Francis S. Chase and Harold A. Anderson. Cloth. Pages xiv+465. 14.5×23 cm. 1958. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $5.75.

SINGLE SIDEBAND FOR THE RADIO AMATEUR. Paper. 212 pages. 16.5×24 cm. 1958. American Radio Relay League, Inc., West Hartford 7, Conn. Price $1.50.

THE EXPLORATION OF TIME, by R. N. C. Bowen. Cloth. Pages vii+143. 13.5×21.5 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $6.00.

LOOKING AT THE STARS, by Michael W. Ovenden. Cloth. 192 pages. 12×18.5 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $4.75.

THE FINE AND APPLIED ARTS, by Royal Bailey Farnum. Vocational and Professional Monographs. Paper. 39 pages. 15.5×23 cm. 1958. Bellman Publishing Co., Cambridge 38, Massachusetts. Price $1.00.

THE SCIENTIFIC INSTRUMENT INDUSTRY, by James R. Irving. Vocational and Professional Monographs. Paper. 60 pages. 15.5×23 cm. 1958. Bellman Publishing Co., Cambridge 38, Massachusetts. Price $1.00.

SCIENCE AND EDUCATION AT THE CROSSROADS, by Joseph W. Still. Cloth. Pages viii+140. 15×23 cm. 1958. Public Affairs Press, 419 New Jersey Ave., S.E. Washington 3, D. C. Price $3.75.

ADVENTURES IN THE WORLD OF SCIENCE, by Charles G. Abbot. Cloth. Pages ix+150. 15×23 cm. 1958. Public Affairs Press, 419 New Jersey Ave., S.E., Washington 3, D. C. Price $3.50.

SOLVING THE SCIENTIST SHORTAGE, by David C. Greenwood, *University of California*. Paper. Pages viii+68. 15×23 cm. 1958. Public Affairs Press, 419 New Jersey Ave., S.E., Washington 3, D. C. Price $2.00.

WORKBOOK FOR ALGEBRA ONE, by Oscar E. Miller and Myrrl Summers. Paper. Pages iv+184. 21.5×28 cm. 1958. World Book Co., Yonkers-on-Hudson, N. Y. Price $1.32.

THE GANG, A Study in Adolescent Behavior, by Herbert A. Bloch, *Professor of Sociology and Anthropology, Brooklyn College*, and Arthur Niederhoffer, *Lieutenant, Police Department, New York City*. Cloth. Pages xv+231. 13.5×21 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $6.00.

SCIENCE THEORY AND MAN, by Erwin C. Schrodinger. Paper. Pages xxiv+223. 13.5×21.5 cm. 1958. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.35.

THE PRINCIPLES OF SCIENCE, A TREATISE ON LOGIC AND SCIENTIFIC METHOD, by W. Stanley Jevons. Paper. Pages liii+786. 13.5×21.5 cm. 1958. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $2.98.

ELEMENTARY TEACHERS GUIDE TO FREE CURRICULUM MATERIALS, edited by Patricia H. Suttles. Paper. Pages xv+318. 21.5×27.5 cm. 1958. Educators Progress Service, Randolph, Wisconsin. Price $6.50.

AN INTRODUCTION TO MATHEMATICS, by Alfred North Whitehead. Paper. Pages v+191. 12.5×19 cm. 1958. Oxford University Press, 417 Fifth Avenue, New York 16, N. Y. Price $1.50.

WHAT'S HAPPENED TO OUR HIGH SCHOOLS?, by John F. Latimer, *Assistant Dean of Faculties, The George Washington University.* Cloth. Pages vi+196. 15.5×23 cm. 1958. Public Affairs Press, 419 New Jersey Ave., S.E., Washington 3, D. C. Price $3.75.

THE TRAVELING HIGH SCHOOL SCIENCE LIBRARY, Fourth Edition, by Hilary J. Deason, *Director, High School Science Library Program.* Paper. 68 pages. 15×23 cm. 1958. American Association for the Advancement of Science and The National Science Foundation. Washington, D. C. Price $.25.

THE STRANGEST THINGS IN THE WORLD, by Thomas R. Henry. Cloth. Pages vii+200. 15×22.5 cm. 1958. Public Affairs Press, 419 New Jersey Ave., S.E., Washington 3, D. C. Price $3.50.

HOW TO STUDY, HOW TO SOLVE, Student Edition, by H. M. Dadourian. Paper. Pages iv+43. 15×23 cm. 1958. Addison-Wesley Publishing Co., Inc., Reading, Mass. Price $.50.

BUDGETING YOUR CAR, by Cyrus A. Martin. Paper. 28 pages. 15×23 cm. 1958. Public Affairs Press, 419 New Jersey Ave., S.E., Washington 3, D. C. Price $1.00.

WOODLAND ECOLOGY, by Ernest Neal, *Head of Science Dept., Taunton School.* Cloth. Pages xii+117. 1958. Harvard University Press, Cambridge, Mass. Price $1.75.

CONCEPTS OF EQUATION AND INEQUALITY, Sample classroom unit for high school algebra students. Paper. 11 pages. 15.5×23 cm. 1958. Commission on Mathematics, College Entrance Examination Board, 425 W. 117 St., New York 27, N. Y. Price $.15.

COLLEGE BOARD SCORE REPORTS, A guide for counselors. Paper. 31 pages. 14×18 cm. 1958. College Entrance Examination Board, c/o Educational Testing Service, Box 592, Princeton, N. J. Price $.15.

TESTS IN BIOLOGY, to accompany Curtis and Urban's BIOLOGY—THE LIVING WORLD, by Francis D. Curtis. Paper. Pages iii+88. 23×28 cm. 1958. Ginn and Co., Statler Building, Boston, Mass.

ACTIVITIES IN BIOLOGY THE LIVING WORLD, by Francis D. Curtis. Paper. Pages viii+284. 23×28 cm. 1958. Ginn and Co., Statler Building, Boston, Mass.

Book Reviews

COLLEGE ALGEBRA, FOURTH EDITION, by Joseph B. Rosenbach and Edwin A. Whitman, *Carnegie Institute of Technology*, Bruce E. Meserve, *New Jersey State Teachers College at Montclair*, Philip M. Whitman, *The Johns Hopkins University*. Cloth. pp. xiv+579+xlvi. 15.5×23.5 cm. 1958. Ginn and Company, Statler Building, Boston 17, Mass. Price $5.25.

The revised edition of this text was reviewed by this reviewer in SCHOOL SCIENCE AND MATHEMATICS for November, 1939 (p. 795) and the third edition was reviewed in March, 1950 (p. 250–1). The favorable comments previously made are still valid. This is what might be termed a standard text of the traditional type, made more than usually valuable by the historical notes, ample problems (including problems which the student will encounter in later courses), and superior rigor in treatment. As illustrative of careful usage, one might mention the definition of a mantissa of a logarithm, or the care used in defining negative or fractional exponents. After a careful definition of a function, the authors take care to point out that different usages of the word "function" are quite common, and mention some of the variations. It would be helpful if this were a more common practice.

The fourth edition includes a chapter treating elementary topics in statistics; there is brief discussion of such topics as finite differences, the summation notation, the exponential form of a complex number, but the arrangement is such that these can be omitted without any loss of continuity. There is less space devoted to topics in the mathematics of investment than in earlier editions. The reviewer was pleased to find some exercises in mathematical induction which are not true theorems, or for which an invalid proof is given (suggested in a review of an earlier edition). On page 377 problems 52 to 63 might have used logarithms to bases other than ten, making it impossible for the student to use tables in solving, rather than using properties of logarithms.

This is an outstanding text of the traditional type. Perhaps the attempt to provide extreme flexibility, and include a wide variety of topics makes the text somewhat more bulky than some would prefer.

CECIL B. READ
University of Wichita
Wichita, Kansas

QUALITATIVE ANALYSIS, by Therald Moeller, *Professor of Inorganic Chemistry, University of Illinois*. Cloth. Pages x+550. 15×23 cm. 1958. McGraw-Hill Book Inc., 330 West 42nd Street, New York 36, New York. Price $6.50.

The sub title of this new text, *An Introduction to Equilibrium and Solution Chemistry*, is very descriptive of this particular book. The author is an experienced writer since he has published over 100 research papers as well as having authored a widely used advanced textbook in Inorganic Chemistry. Also, Dr. Moeller is Editor-in-Chief of Volume V of the well known "Inorganic Synthesis" series published by McGraw-Hill.

In his preface to this textbook Dr. Moeller states: "In common with many other teachers I believe that no discipline in beginning chemistry is as potentially effective as qualitative analysis in giving the student an interesting and active integration of necessary descriptive fact with the elements of equilibrium-principles and solution theory that are so essential in his subsequent courses".

This qualitative text is somewhat unusual in that it completely covers the theory and practice of anion analysis of a group of 24 anions before going into the consideration of cations and their identification. In his preface Dr. Moeller gives his reasons for this procedure as follows:

"1. The useful chemistry of the cations is often dependent upon the anions present. It is logical, therefore, that the student have prior knowledge of the anions.

2. The laboratory investigation of the anions is less readily reduced to routine

than that of the cations and thus requires that the student develop a reasoning and logical experimental approach and that he learn to interpret all his observations. This training is invaluable in his subsequent study of the cations.

3. The chemistry of the anions is less amenable to illustrating the principles of solution chemistry than that of the cations. The student can thus develop a background of principles before it is necessary to apply them for maximum understanding of the laboratory work."

The text is divided into three parts:

Part I. Principles of Solution Chemistry

Part II. Chemical Characteristics of the More Common Ionic Species

Part III. Laboratory Investigation of the Characteristics of the More Common Ionic Species

Part III. is followed by a rather complete appendixes which include many equilibrium constant tables along with suggestions for solving chemical problems.

At the end of many of the chapters are thought provoking exercises.

The publishing company has used excellent paper and good type in the format of the book. The reviewer feels that the author succeeds very well in leading the student through laboratory exercises in such a way as to make the student feel that he is actually developing his own procedure for analysis. The reviewer suggests that the book is too advanced to be used as a part of the first year course but should follow a year of rigidly developed general chemistry as a sophomore course. A qualitative course based on this text should make an excellent background for a good solid course in quantitative analysis: the semi micro technique is used throughout and the cation scheme is described for the use of either H_2S or thioacetamide as the group reagent in groups two and four.

This is a well written text-book which should have a wide sale.

GERALD OSBORN
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Kalamazoo, Michigan

TEACHING HIGH SCHOOL SCIENCE: A BOOK OF METHODS, by Paul F. Brandwein, Fletcher G. Watson, and Paul E. Blackwood. Cloth. Pages xxi+568. 16.5×23 cm. 1958. Harcourt, Brace and Co., 383 Madison Ave., New York, N. Y.

Within the past few years there has been a rash of new publications in science methods. All have been produced by men of stature in the field and have contributed many fine ideas to science education. However, the advent of another publication such as this one suggests that the following questions be posed:

1. Is the publication well-written and understandable?
2. Does the publication cover the field as well or better than its competition?
3. Is the publication written in a manner understandable to the average classroom teacher?
4. Does the publication contribute anything new to what has already been written about methods of science teaching?

The reviewer has read this document twice and has re-read several sections three or four times. He has mixed opinions about it.

Without doubt the document is extremely well-written and is understandable to the qualified teacher in science. All statements that may evoke controversy are cited and sources given. The fields ordinarily covered in a methods book in science are covered more satisfactorily in this book (in nearly 500 pages) than they are in any other similar publication.

The book is built around six major sections, namely, the meaning and implications of scientific method and scientific behavior, methods in the classroom, science curriculum, evaluation of science teaching, instructional aids and community action that has been taken to improve science teaching. Without question they are done well and thoroughly.

However, the reviewer believes that its value for assisting the new classroom teacher and in some cases the experienced one, may be limited in certain ways:

1. The book contains so much material and so many illustrations about science teaching that one is left gasping. Between its covers clearly every possible method of science teaching is covered, including the ones utilized by any teacher who reads the book. Thus, the question, "What seems to be the direction to take?" is left unanswered. This is not a criticism, but merely a descriptive statement about the book, since in the foreword it is clearly mentioned, "we feel strongly that a book of methods should not be prescriptive but illustrative, and we have organized this book so as to carry out this belief." In terms of that philosophy, the book is excellent. However, the reviewer questions whether or not at present a few of the more desirable directions may better be pointed out, rather than all directions.

2. The book fails to come clearly to grips with what the authors believe to be the most important needs in science education at present.

a. The development of a clear-cut statement, in words of one syllable that all science teachers will understand, concerning what a program of science should enable a student to do better.

b. A series of proposals, clear-cut and understandable, concerning how the program of science teaching should be articulated from grade level to grade level.

The points raised above should not be construed as a criticism of what the book *is*, but rather of what it *isn't*!

Anyone seeking a clear, lucid discussion of the problems *usually covered* in a science methods book will find this one among the best. The writer will recommend it on that basis. In fact, he intends to use it himself.

However, he will continue to look for "the better mousetrap."

George G. Mallinson

Elements of Mathematical Biology, by Alfred J. Lotka. Paper. Pages xxx +465. 13.5×21.5 cm. 1956. Dover Publications, Inc., 920 Broadway, New York 10, N.Y. Price $2.45.

This publication is not a new one. However, it has taken on increased significance during the past few years as attempts have been made to apply modern mathematics to the various fields of biology. It was first published under the title *Elements of Physical Biology* in 1924. However, the author's original plan of the work and his first publication dealing with the topic appeared in 1902 and 1907, respectively. The publication is of course a classic in its field and attained great respect among the pioneers who sought to quantify various aspects of biology. Since these early days this field of biology has been explored more and more intensively. Hence, the Dover paper-bound, and somewhat abridged edition brings a classic to those who may not have had the opportunity to peruse the original document.

In essence the publication attempts to show how the laws of thermodynamics, kinetics and equilibrium can be used to explain some of the phenomena related to the traditional areas of biology such as evolution, growth, ecology, and continuity of species. Without doubt the effort is most impressive.

It is of course obvious that the author utilized the areas of mathematics under which probability and predictability are encompassed, in order to describe the biological phenomena. Most of the classical fields of mathematics would not have allowed the flexibility needed by the author to have supported his theories and hypotheses.

This reviewer at times became confused as to the aim of the treatise. The function of the mathematical treatment of various aspects of biology vacillated from description to quantification to prediction, without always a clear demarcation. This may well be attributed to the pioneering quality of the document.

The Dover edition is designed definitely for the college teacher of biology or professional biologist. The reviewer would suggest that a truly educated biologist in the categories mentioned should without question read either the original volume or the Dover edition. The reviewer would recommend the Dover edition.

It is not easy reading nor always interesting. It is, however, stimulating and demands the type of biological analysis that every biologist should experience.

G.G.M.

"STARTLING" MACHINE CAN THINK LIKE HUMAN BRAIN

The first non-living mechanism able to "perceive, recognize and identify its surroundings without human training or control" has been developed for the U. S. Navy.

The electronic device, which officers hesitate to call a machine because it is so much like a "human being without life," has been demonstrated in a preliminary form.

"Perceptron," as it is called, needs no "priming." It is not necessary to introduce it to surroundings and circumstances, record the data involved and then store them for future comparison as is the case with present "mechanical brains." The Perceptron literally teaches itself to recognize objects the first time it encounters them.

It uses a camera-type lens to scan objects or survey situations, and an electrical impulse system patterned point-by-point after the human brain does the interpreting.

In one early experiment, Perceptron was shown 100 squares located at random either on the right or left side of a field. In 100 trials, Perceptron was able to "say" correctly 97 times whether a square was located on the right or left. Researchers said it was "obvious" after the machine had seen only 30 to 40 squares that it had learned to recognize the difference between right and left, almost the same way a child learns.

Printed pages, longhand letters and even speech commands are within reach of the device. Only one more step of development, a difficult step, is needed for the device to hear speech in one language and then reproduce it either in writing or verbally in another language.

STUDY EFFECTS OF JET TRAVEL ON INSECT PESTS

Jet airplanes may turn out to be very effective insecticides as they deal the deathblow to hitchhiking "bugs."

Whenever aircraft from a foreign country land, the planes are inspected inside and out to ensure that no harmful insects gain entrance. Now, with the jet age here, new quarantine problems arise concerning the effects of high altitude, temperature extremes and high speeds on insect mortality.

Experiments conducted by U.S. Department of Agriculture entomologists indicate that the low temperatures of unheated parts of planes flown at high altitudes make it difficult for hitchhiking insects to survive. In actual field test using armyworm eggs, the scientists found the eggs, usually the most difficult stage to destroy, could not survive a ride on a jet's wings. Laboratory tests show insects cannot stand as high temperature as man.

HIGHWAY WARNING SYSTEM

Superhighways can now be equipped with an automatic warning system that posts reduced speed limits for any of a number of reasons and also tells the motorist why the limit has been reduced.

This is made possible through an interlocking system of speed limit and danger signs designed to sense for themselves such dangers as fog, rain or ice.

According to the system's inventor, Louis P. Clark of Broomall, Pa., such condition detectors as ground-buried thermometers, moisture detectors and photo-cells could tell the sign near it what is the condition of the highway in that specific area. A control box, receiving these signals, would then post a predetermined speed limit for the condition and either light up a "Danger" signal or "Fog," for example.

Mr. Clark has also provided a central control whereby the local signs which may differ from one another, can be controlled from a highway patrol car or a booth to override the local warnings.

STUDY MEANS OF EXTRACTING OCEAN METALS ECONOMICALLY

How to extract the metals contained in the billions of tons of nodules on the ocean's floor is being studied by two University of California engineers.

Nodules are small, brown-black stones, usually less than six inches in diameter, that dot some 40,000,000 square miles of the floors of the world's oceans. Millions of years ago they began growing around bits of volcanic glass, pumice, clay and such oddities as sharks' teeth.

It is believed the nodules could be recovered with present technology, using such equipment as a huge dredge resembling a vacuum cleaner, artificial light sources and television cameras.

The problem is how to process the nodules and separate them into metals at competitive prices.

Mining nodules could be especially important in giving the United States a source of the important mineral, manganese. Almost all manganese used in the United States is imported.

Recently scientists at the University of California's Scripps Institution of Oceanography, La Jolla, discovered and explored a huge store of nodules in relatively shallow waters off the French-owned Tuamotu Islands in the South Pacific.

Nodules recovered from this area during Scripps's Downwind Expedition contained approximately 25% manganese, 15% iron, and less amounts of nickel, copper and cobalt, as well as a number of rare earth metals.

A new mineral processing technique for nodule mining is needed, since no suitable processing method exists.